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OHIO RIVER VALLEY STUDY
Sites, Methods, Data Summary for 1980

Volume 2. Appendices

by

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The Ohio River Valley Study was initiated to gather air quality data at sites representative of regional conditions in an area where current coal usage and projected increases are exceptionally large. These data were intended for use in developing source apportionment calculations to attempt to identify species contributing to fine and coarse particle mass and to identify the major pollution sources responsible for these ambient particles. Special emphasis was also directed to chemical and physical analysis of the aerosols and gases to estimate the impact of emissions from coal-fired power plants on air quality at these Ohio River Valley monitoring sites.

This report describes procedures for site location and for station preparation, operation, and periodic audits. Data summaries are presented for the period May through December 1980. Measurements included atmospheric concentrations of nitrogen oxides, sulfur dioxide, ozone, and peroxyacetyl nitrate; local meteorology; aerosol mass and composition; total suspended particulate; and precipitation. Special analyses for speciation of sulfur aerosols began in December 1980. Measurements of nitric acid and ammonia were made during the summer of 1981; results will be presented in a subsequent report.

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ABSTRACT

The Ohio River Valley Study was initiated to gather air quality data at sites representative of regional conditions in an area where current coal usage and projected increases are exceptionally large. These data were intended for use in developing source apportionment calculations to attempt to identify species contributing to fine and coarse particle mass and to identify the major pollution sources responsible for these ambient particles. Special emphasis was also directed to chemical and physical analysis of the aerosols and gases to estimate the impact of emissions from coal-fired power plants on air quality at these Ohio River Valley monitoring sites.

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Site study and selection were performed under Grant R-805812 by Battelle Columbus Laboratories under the sponsorship of the U.S. Environmental Protection Agency. The stations were prepared under Contract 68-02-2566 by Northrop Services, Inc. - Environmental Sciences under the sponsorship of the U.S. Environmental Protection Agency. The data (except for particulate sulfur measurements) were collected under Contract 68-02-3288 by Mead Technology Laboratories under the sponsorship of the U.S. Environmental Protection Agency. Particulate sulfur measurements were performed by the Oregon Graduate Center under Cooperative Agreement CR807654 with the U.S. Environmental Protection Agency. The stations were audited under Contract 68-02-3285 by Northrop Services, Inc. - Environmental Sciences under the sponsorship of the U.S. Environmental Protection Agency.

This report refers to data collected during the period May 1, 1980 to December 31, 1980.

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ACKNOWLEDGMENTS

This study was made possible by the skills and dedication of the station operators, Russell Arey, David Morehart, and Mark Sears of Mead Technology Laboratories (MTL). Daniel Strait (MTL) assumed management of the program during several months in 1981.

Joseph Williams of Northrop Services, Inc. - Environmental Sciences (NSI-ES) carried out the reconstruction of the experimental stations and setup and testing of the instrumentation, and took primary responsibility for station audits during the period of data acquisition. George Russwurm, Keith Kronmiller, Edward Tew, and Steven Lassiter (NSI-ES) also participated in station audits.

Elemental and mass analyses of aerosol samples were provided by Dr. William Courtney, Christopher Pressley, Carolyn Owen, and Brenda Mullen (NSI-ES). Precipitation analyses during the latter part of the study were provided by Dr. John Tesch and Judith Hunt (NSI-ES).

Professor James Huntzicker and Robert Cary (Oregon Graduate Center) provided their particle sulfur analyzer and analyzed the data. Professor Briant Davis (South Dakota School of Mines and Technology) performed X-ray diffraction analysis of aerosols. Drs. Chester Spicer and Michael Holdren

(Battelle Columbus Laboratories) performed audits of the PAN analyzers during the summer of 1981.

The U.S. Environmental Protection Agency is indebted to the station site landowners, Mr. and Mrs. Ray Johnson (Morganfield, Kentucky), Mr. and Mrs. Harry Lang (Brookville, Indiana), and Mr. and Mrs. Phil Cowan (Loudenville, Ohio), for their cooperation.

APPENDIX A

THE SULFUR PARTICLE ANALYZER

James Huntzicker and colleagues performed the measurements for particulate sulfur under Cooperative Agreement CR807654 between EPA and the Oregon Graduate Center. This appendix consists of a report prepared under that cooperative agreement.

Measurement of Total Particulate Sulfur and Sulfuric Acid in the Ohio River Basin

EPA Cooperative Agreement: CR807654

Progress Report

James J. Huntzicker
Robert A. Cary
Robert S. Hoffman

Department of Environmental Science
Oregon Graduate Center
19600 N.W. Walker Road
Beaverton, Oregon 97006

September 11, 1981

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In September, 1980 the Oregon Graduate Center (OGC) and the Environmental Protection Agency entered into Cooperative Agreement (CR 806274) by which OGC would provide continuous measurements of total aerosol sulfate, sulfuric acid and "refractory" (or metal) sulfates at one of the stations in the EPA Ohio River Valley program. This report describes the activities conducted during 1980 under this agreement. The report begins with a description of the instrument and then presents the results obtained through December 1980.

Instrument

All measurements were made with the in situ particulate sulfur analyzer developed with support from EPA grant 804750. This instrument measures total particulate sulfur, sulfuric acid, and refractory sulfates. A schematic of the instrument is shown in Figure 1. The primary sulfur detector is the Meloy SA-285 flame photometric sulfur monitor. It measures the chemiluminescence which results when either gaseous (e.g. SO_2) or particulate (e.g. $(NH_4)_2\ SO_4$, H_2SO_4, etc.) sulfur is introduced into the hydrogen-air flame. The flame photometer is made specific to particulate sulfur by passing the sample air through a diffusion stripper (denuder) to remove SO_2, H_2S, and other sulfur containing gases. The stripper is a hollow stainless steel tube into which is inserted a cylinder of Whatman 41 filter paper impregnated with $Pb(CH_3CO_2)_2$ and $AgNO_3$.

Speciation is achieved by the heated tube system shown in Figure 1. Valve V1 routes the sample air sequentially through each of the four channels. Channel 1, which consists of a stainless steel tube heated to 250°C transmits only refractory sulfur species. The 130°C channel transmits

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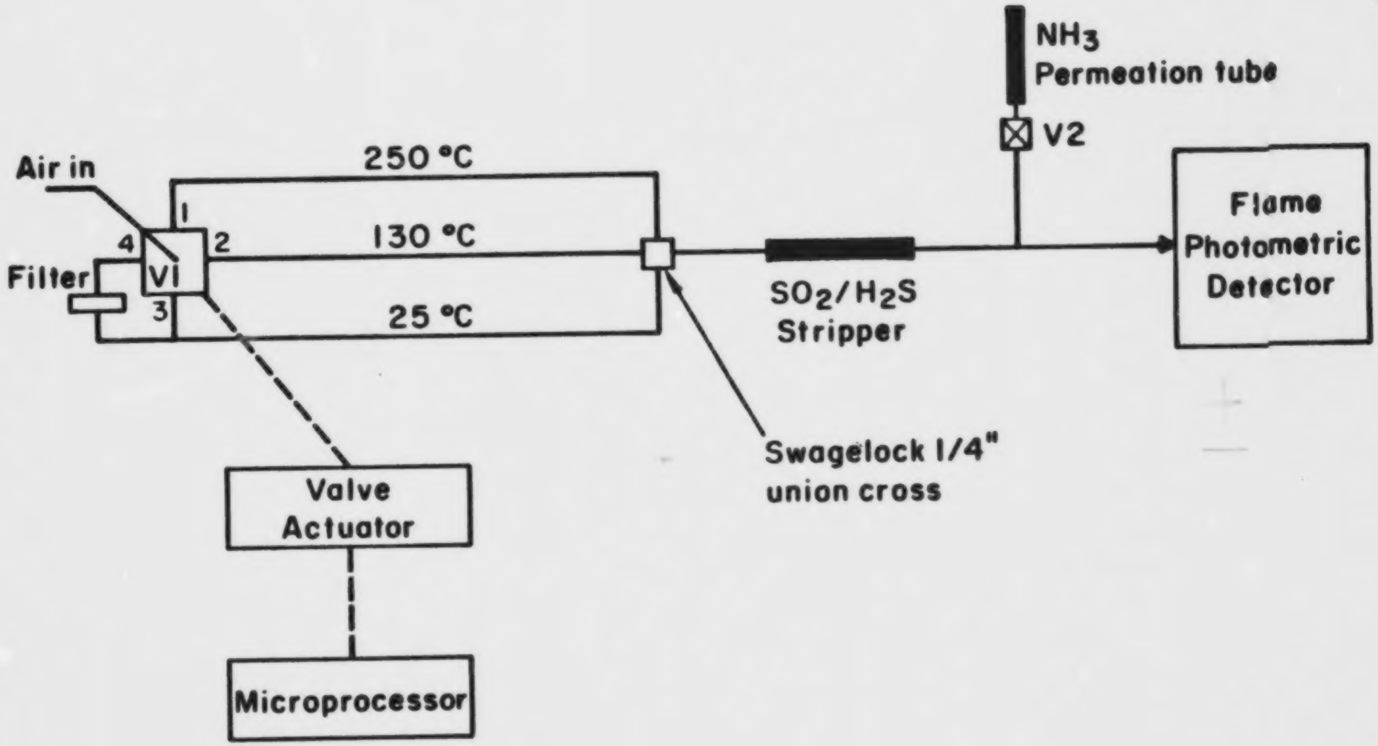
Air in
Filter
1
2
3
4
VI
250 °C
130 °C
25 °C
Swagelock 1/4" union cross
SO_2/H_2S Stripper
NH_3 Permeation tube
V2
Flame Photometric Detector
Valve Actuator
Microprocessor

Figure 1. Particulate sulfur monitor flow system. VI is a five-port ball valve. and V2 is the ammonia shut-off valve.

total particulate sulfur minus volatilizable sulfuric acid, and the 25°C channel measures total particulate sulfur. Volatilizable or excess sulfuric acid is defined as the amount of acidity (as sulfate) in excess of NH_4HSO_4 stoichiometry if the acidic and ammonium fractions are internally mixed or in excess of $(NH_4)_2SO_4$ stoichiometry if the acidic and ammonium fractions are externally mixed. Since the state of mixing is, in general, not _a priori_ known, the total titratable acidity associated with sulfate aerosol cannot be determined. In the fourth channel the air passes through a glass fiber filter which removes all particles and establishes the instrument baseline. One complete measurement cycle involves all four channels, and the baseline is updated for each measurement cycle. A complete cyle requires 15 minutes.

The position of the valve V1 and all electronic functions are controlled by a microcomputer built around a Motorola 6802 microprocessor. A block diagram of the microcomputer is shown in Figure 2. The microcomputer measures the current output of the flame photometer phototube, digitizes and integrates it, and stores the integrated value on a cassette magnetic tape. The digitized signal is also linearized according to the equation: $FPD = aS^n + b$ where FPD is the digitized flame photometric detector output, S is the sulfur concentration, a is a multiplying factor, n is typically ∿ 1.6, and b is used to correct for any offset between the baseline channel and channels 1-3 under zero sulfur conditions. The linearized signal as well as the non-linearized FPD output are presented to a strip chart recorder.

The data which were stored on the cassette magnetic tape are processed on the OGC Prime 350 computer. Hourly averages of total

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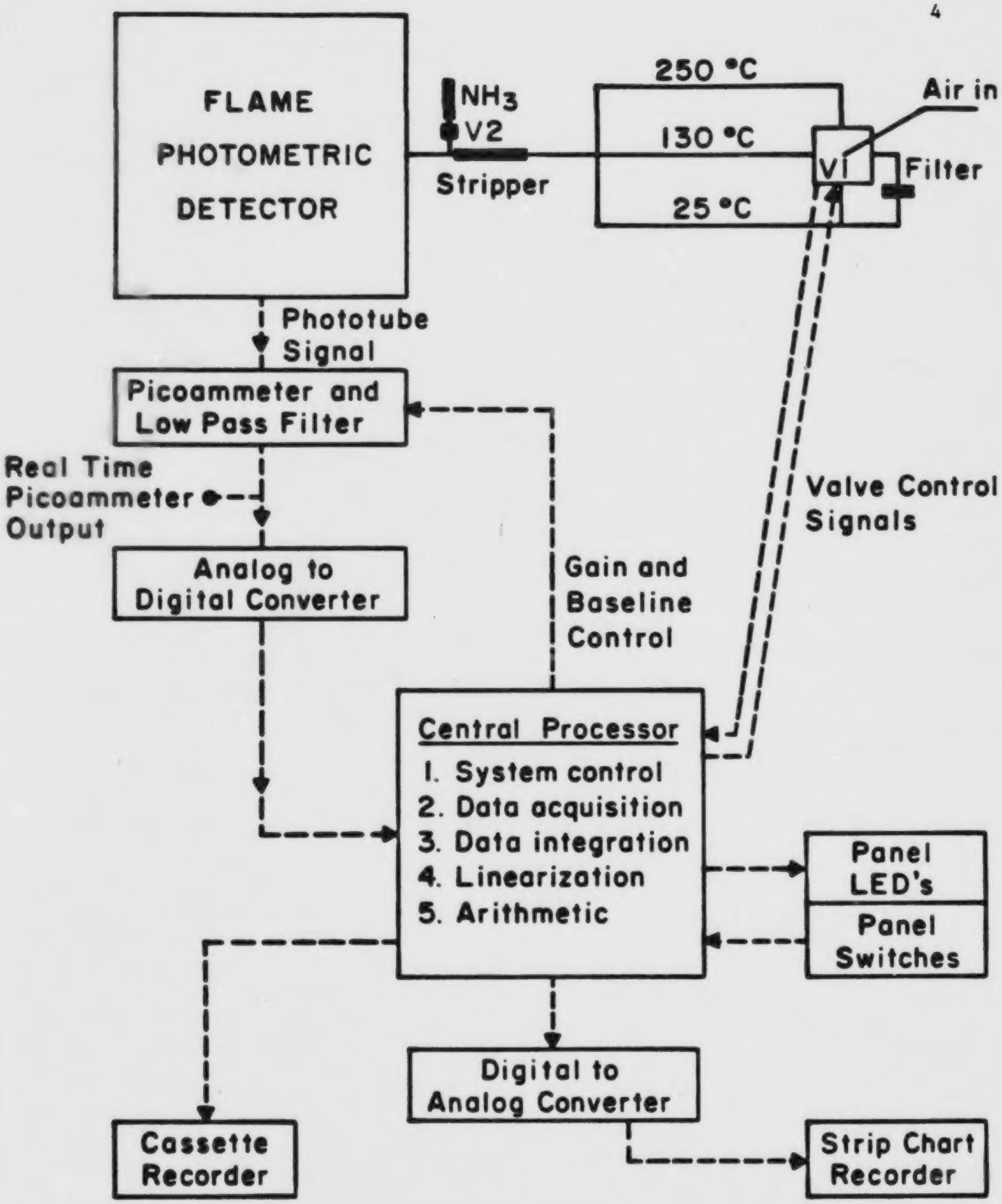
FLAME
PHOTOMETRIC
DETECTOR
NH_3
V2
Stripper
250 °C
130 °C
25 °C
V1
Air in
Filter
Phototube Signal
Picoammeter and Low Pass Filter
Real Time Picoammeter Output
Analog to Digital Converter
Gain and Baseline Control
Valve Control Signals
Central Processor
1. System control
2. Data acquisition
3. Data integration
4. Linearization
5. Arithmetic
Panel LED's
Panel Switches
Digital to Analog Converter
Cassette Recorder
Strip Chart Recorder

Figure 2. Microprocessor control system for the particulate sulfur monitor.

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particulate sulfur, excess sulfuric acid, and refractory sulfur are available in both tabular and graphical form.

Experimental

The instrument was calibrated against measured concentrations of laboratory $(NH_4)_2SO_4$ aerosol. This aerosol was produced by nebulizing aqueous solutions of $(NH_4)_2SO_4$ and measuring the concentration of $(NH_4)_2SO_4$ aerosol by filtration followed by aqueous extraction and flash volatilization analysis (1). The instrument was installed at the Brookville, Indiana, site on November 20-21, 1980.

Because it was anticipated that the only sulfur gases present at that site would be SO_2 and H_2S, the diffusion stripper was impregnated with $Pb(CH_3CO_2)$ but no $AgNO_3$. However, in the first three weeks of operation it became apparent that this stripper was not removing all of the ambient sulfur gases. This was evidenced by a highly variable baseline. This was corrected by adding a $Pb(CH_3CO_2)_2$-$AgNO_3$ just upstream of valve V1 in Figure 1. Because of this problem valid data were not collected until December 15, 1980.

Results

Hourly average concentrations at Brookville, Indiana, for total particulate sulfur (as sulfate) and refractory sulfur are shown for the period December 15-28 in Figures 3 and 4. The average and maximum concentrations for total and refractory sulfur are listed in Table 1. Within the limits of the analytical uncertainty ($\pm 2\ \mu g(SO_4^{=})/m^3$) no excess acidity was observed.

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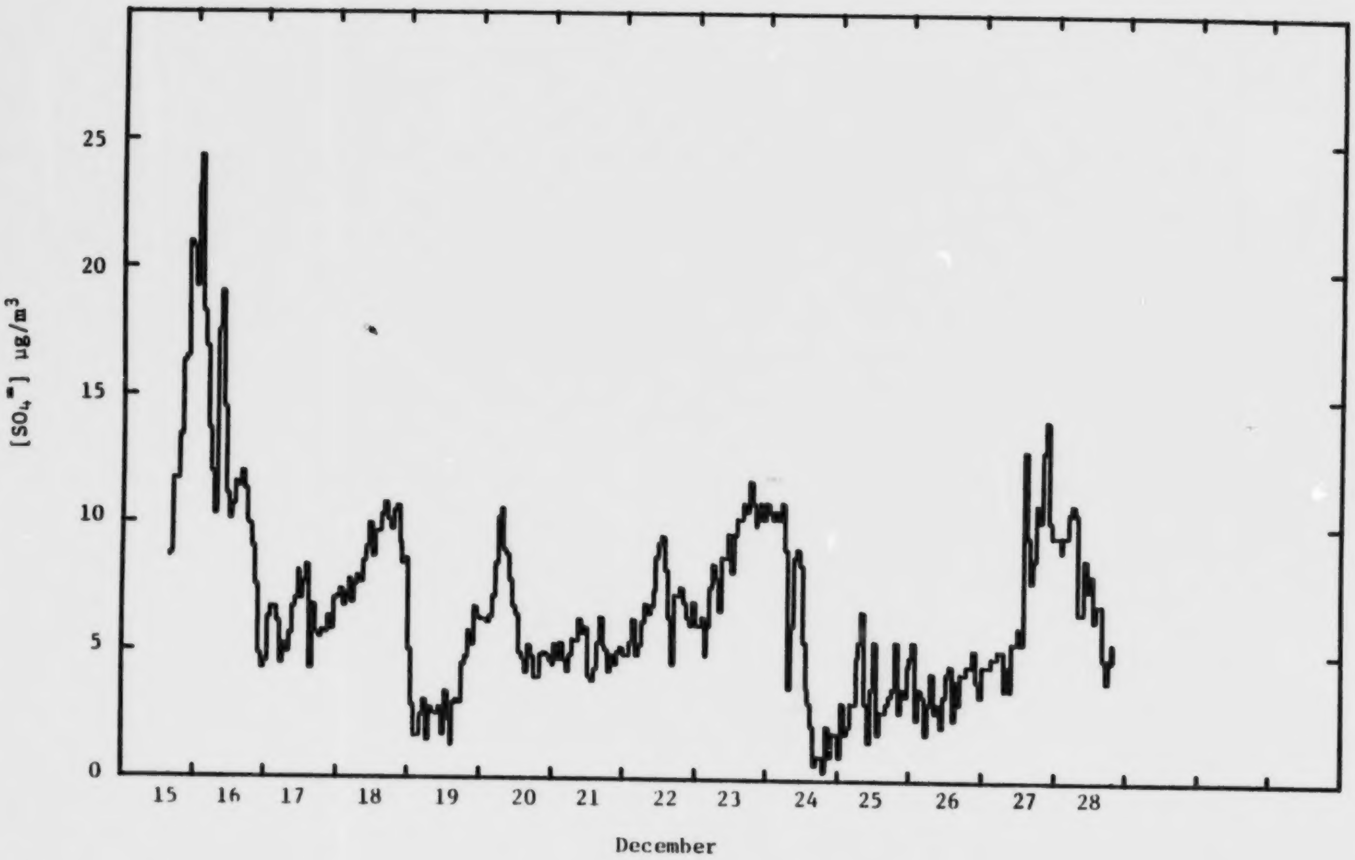

Figure 3. Total aerosol sulfur (as $SO_4^=$) at Brookville, Indiana, December, 1980

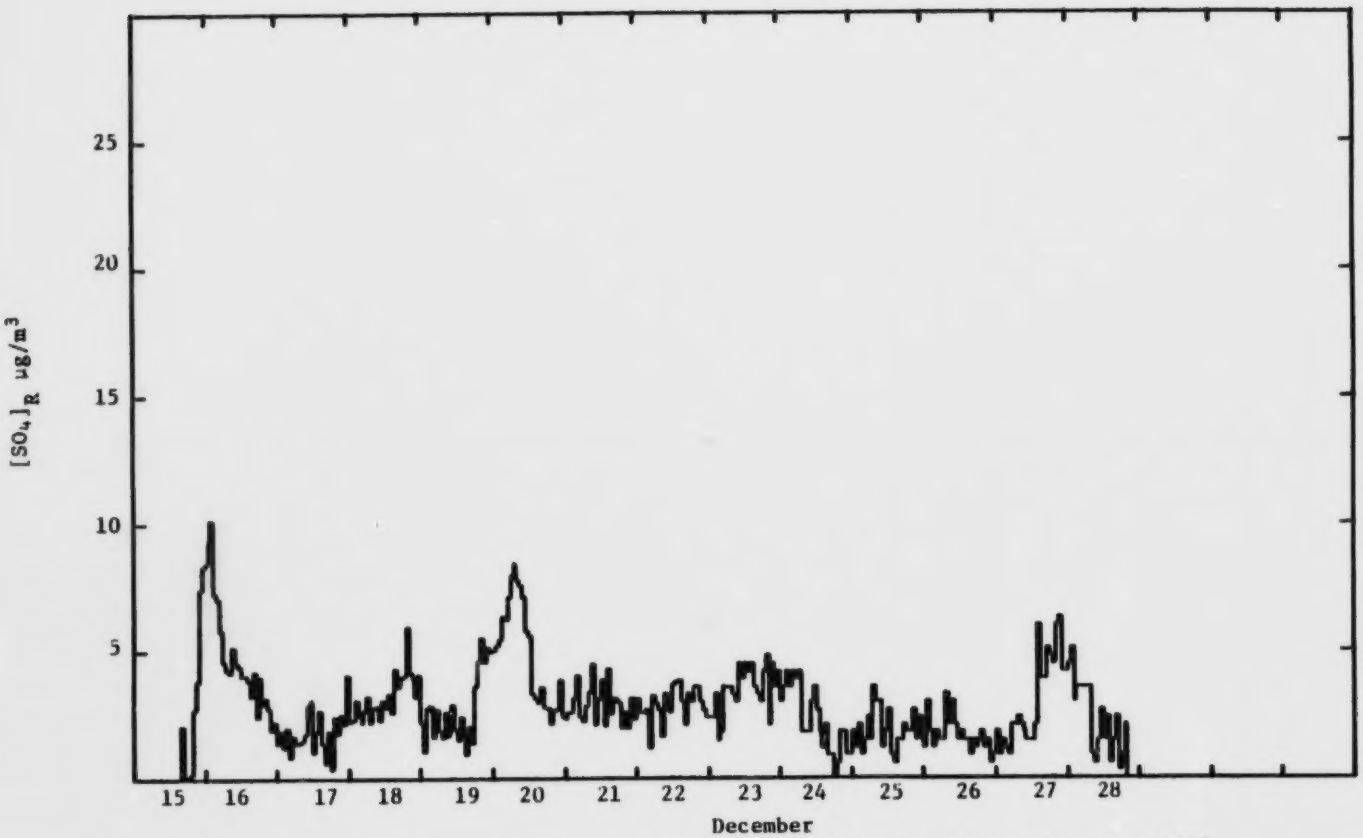

Figure 4. Refractory aerosol sulfur (as $SO_4^=$) at Brookville, Indiana, December 1980

Table 1. Average and maximum concentrations of total and refractory aerosol sulfur (as $SO_4^=$) in Brookville, Indiana, for the period December 15-30, 1980.

	Average μg($SO_4^=$)/m^3	**Maximum** μg($SO_4^=$)/m^3
Total	6.8	24
Refractory	2.9	10

The most interesting feature of these data is the relatively high fraction of aerosol sulfur which is refractory. In Figure 5 both total and refractory sulfate are plotted for the period December 15-21. On December 19 and 20 almost all the aerosol sulfur is refractory. In Figure 6, f_A, the mole fraction of aerosol sulfur (i.e. $\frac{S_A}{S_A+S_g}$ where S_A is aerosol phase sulfur and S_g as gas phase sulfur), and the concentration of SO_2 are plotted for the period December 15-21. In general, there is a strong anti-correlation between f_A and $[SO_2]$. This suggests that peaks in $[SO_2]$ are of local origin and that insufficient time was available for significant gas to particle conversion during these peak periods. Large (i.e. > 0.3) values of f_A occur only during periods when $[SO_2]$ is low (i.e., < 10 ppb). December 19, when most of the aerosol sulfur was refractory, is one of those periods. However, on December 20 during which most of the aerosol sulfur was also refractory, large values of f_A did not occur. The other distinguishing feature of these two days was the extremely cold weather. On December 19 the average temperature was -7.8°C and on December 20, -11.9°C. Investigation of this period is continuing.

References

1. Continuous measurement and speciation of sulfur-containing aerosols by flame photometry. J. J. Huntzicker, R. S. Hoffman, and C.-S. Ling, Atmos. Environ. 12, 83-88 (1978).

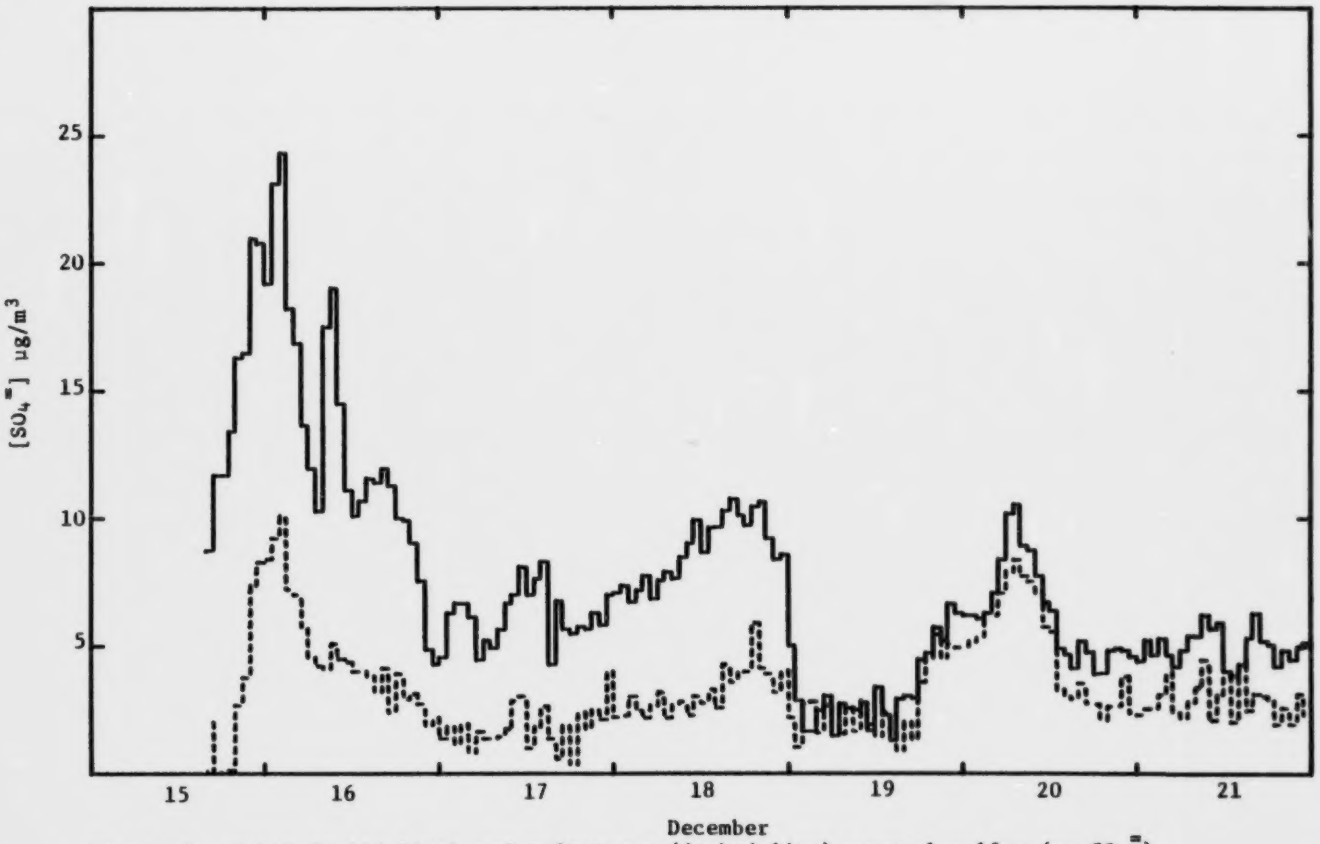

Figure 5. Total (Solid line) and refractory (dashed line) aerosol sulfur (as $SO_4^=$) for December 15-21, 1980, in Brookville, Indiana

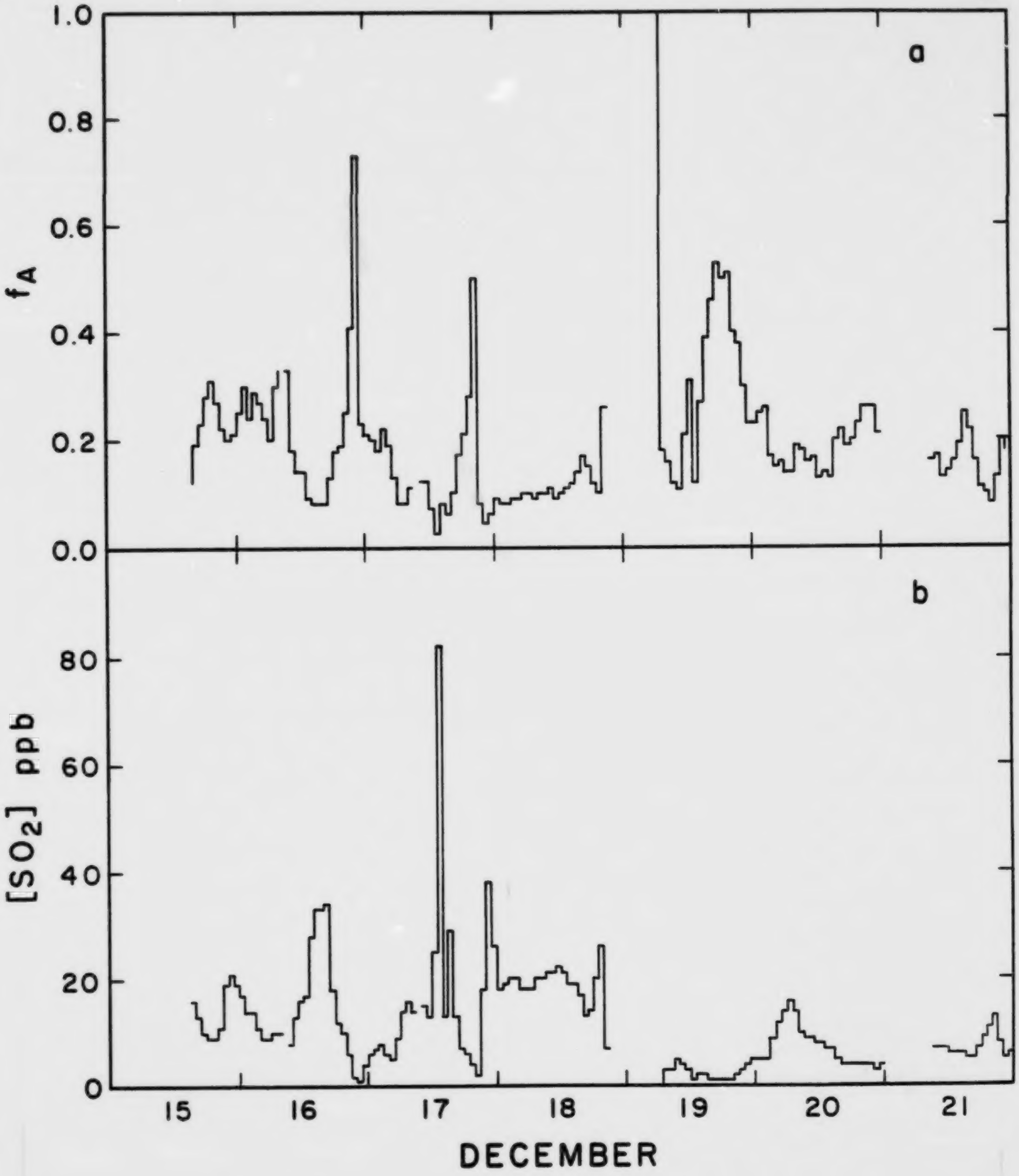

Figure 6. Brookville, Indiana, December 1980

a. Aerosol sulfur mole fraction (f_A)

b. SO_2 concentration

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APPENDIX B

STATION PREPARATION

Northrop Services, Inc. - Environmental Sciences (NSI-ES) designed, constructed, and tested the ORV stations under EPA Contract 68-02-2566. This appendix consists of an NSI-ES report submitted to EPA under that contract.

OHIO RIVER VALLEY STATION PREPARATION

by

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G. M. Russwurm

Environmental Chemistry and Emissions Research
Northrop Services, Inc.
Environmental Sciences

Submitted to:

Inorganic Pollutant Analysis Branch
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Under Contract 68-02-2566

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FOREWORD

This report presents the results of work performed by Northrop Services, Inc.-Environmental Sciences, under Contract Number 68-02-2566 for the Inorganic Pollutant Analysis Branch, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina. This work was conducted in response to Technical Directive 3.6-22 during the period June 1979 to February 1980.

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ABSTRACT

This report describes the design, preparation, and operational testing of three air-monitoring stations by Northrop Services, Inc.--Environmental Sciences (NSI-ES) for the U.S. Environmental Protection Agency (EPA) Environmental Sciences Research Laboratory. These stations will be used to make low-level background measurements of gaseous and particulate pollutants, to evaluate the impact of conversion from oil to coal burning by utilities in the Ohio River Valley area. Each station contains continuous analyzers for ozone, total sulfur, and oxides of nitrogen, an integrating nephelometer, a dichotomous sampler, and a high-volume sampler. (Other systems will be installed by the operating contractor.)

The main components of the air-monitoring system were considered to be the sample inlet, the analyzer or sampler, the electrical supply, the air conditioning system, and the data recording system. The sampler inlet system for each instrument was designed so as to overcome problems encountered with previous air-monitoring stations in preserving the integrity of extremely-low-level samples. The instruments were selected for high sensitivity and stability, as established in previous EPA studies. In each station, a constant voltage regulator was installed to provide electric power to the samplers. The air conditioning system was shown to maintain the station interior within 2°F (1°C) of the setpoint. NSI-ES substantially modified the

software for the data acquisition system to allow isolation of instruments being calibrated and to accomodate meteorological equipment. The data recording system was shown to be accurate to within 0.003 v, which is below the noise level of the analyzers.

After the individual systems were tested and installed, an operational test was made of each station, during which the samplers were audited daily to verify reliable performance. After each station had passed the operational test, personnel from the station operating contractor (Mead Technology Laboratories) were given a three-day familiarization course by NSI-ES personnel.

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SECTION 1

INTRODUCTION

Utilities and industries in the Ohio River Valley are in the process of converting oil-fired generating and heating plants to the use of coal. Plants now under construction or being planned will also be coal-fired. The U.S. Environmental Protection Agency (EPA) Environmental Sciences Research Laboratory (ESRL) has funded a study to gather data concerning air quality before and after these coal-fired plants begin operating, to evaluate their impact on the environment. Station no. 062126 is in Union County, KY, about six miles west of Morganfield. Station no. 062103 is in Franklin County, IN, about five miles east of Brookville. Station no. 062042 is in Ashland County, OH, about ten miles southwest of Loudonville. (See Figure 1.)

Northrop Services, Inc., (NSI) was charged with the task of preparing three air-monitoring stations capable of making baseline concentration measurements of airborne particulate and gaseous pollutants in the Ohio River Valley (ORV). Three major tasks were to be accomplished:

(1) design of the station instrument configuration to eliminate or minimize problems encountered with previous air-monitoring stations,

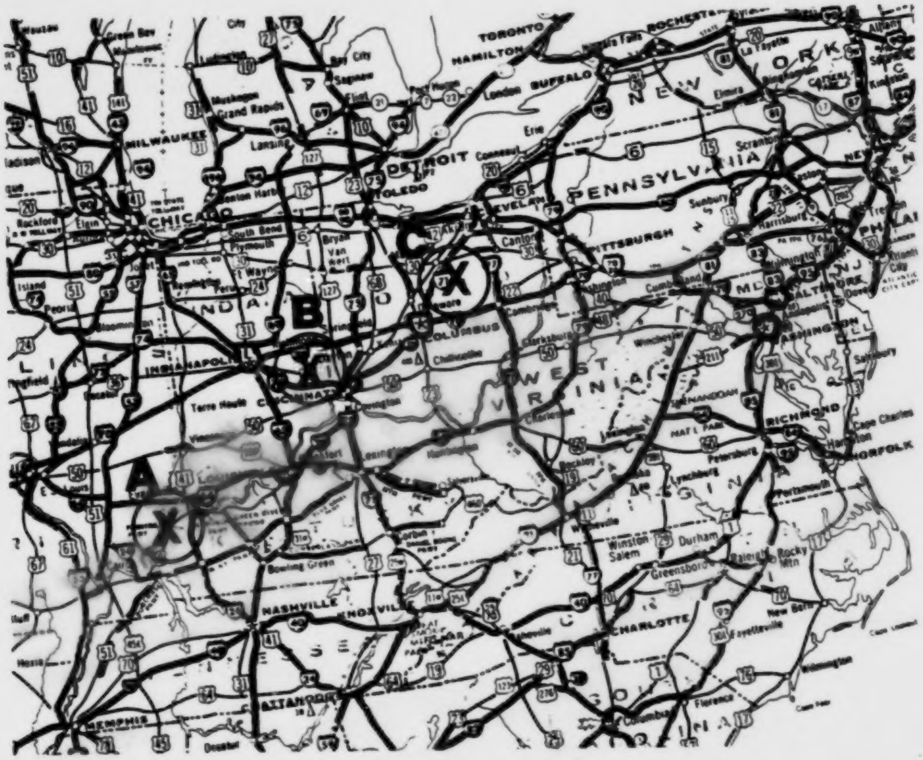
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Figure 1. Location of Ohio River Valley air-monitoring stations. (A) Station no. 062126, Union Co., KY. (B) Station no. 062103, Franklin Co., IN. (C) Station no. 062042, Ashland Co., OH.

(2) performance-testing of the completed stations to demonstrate their reliability and to train the operating personnel, and

(3) preparation of a station operation manual.

In addition to completing the above tasks, NSI also debugged and substantially rewrote the data acquisition system software to facilitate calibration of the air-monitoring instruments and to improve the performance of the data acquisition system.

SECTION 2

REFURBISHING OF AIR-MONITORING STATIONS

At the outset, NSI took possession of three stations that had previously been used in the Regional Air Pollution Study (RAPS) program. The three stations were surveyed to determine what repairs and alterations would be necessary. The old Regional Air Monitoring Station (RAMS) equipment was removed, roof leaks were repaired, new flooring was installed, door locks were replaced, the air-conditioning ducts were opened and vacuumed to remove accumulated dirt, and interior surfaces were repainted where needed.

DESIGN OBJECTIVES

The ORV stations were designed to obtain data of the highest quality and for ease and efficiency of operation. Problems encountered with earlier station designs that were to be addressed included

(1) excessive automation of zero and span check equipment and leak problems associated with solenoid valves;

(2) inconvenient location of instruments for calibration or repair;

(3) condensation and dirt buildup in standard glass inlets for gaseous pollutant analyzers;

(4) collection of copper and carbon particles from the high-volume samplers on dichotomous sampler filters;

(5) the following problems with the dichotomous sampler inlet:
    (a) difficulty of disconnection for flow rate calibration,
    (b) contamination of the filters with metal particles from the connectors, and
    (c) trapping of particles due to misalignment of the butting ends; and

(6) collection of erroneous data due to line voltage fluctuations.

DESIGN SOLUTIONS

These problems were solved as follows:

(1) The instruments specified by EPA were ordered with minimum auto zero and span options.

(2) Station instruments and their sampling ports were located as shown in Figures 2 through 5. Instrument racks were placed to allow free access to the front and rear of rack-mounted equipment. Placement of the analyzers in the racks was planned to allow removal of the top cover from each instrument while it is in the rack.

(3) The inlet system for the gaseous analyzers designed and fabricated by NSI is shown in Figures 6 and 7. The inlets are 13-ft-long by 0.25-in.-outside diameter (OD) Teflon lines placed inside heated sheaths. For each analyzer there is one sample intake line and one calibration line. A thermocouple and electrical heating element are located inside the sheath beside the tubing. Both elements are connected to a proportional controller,

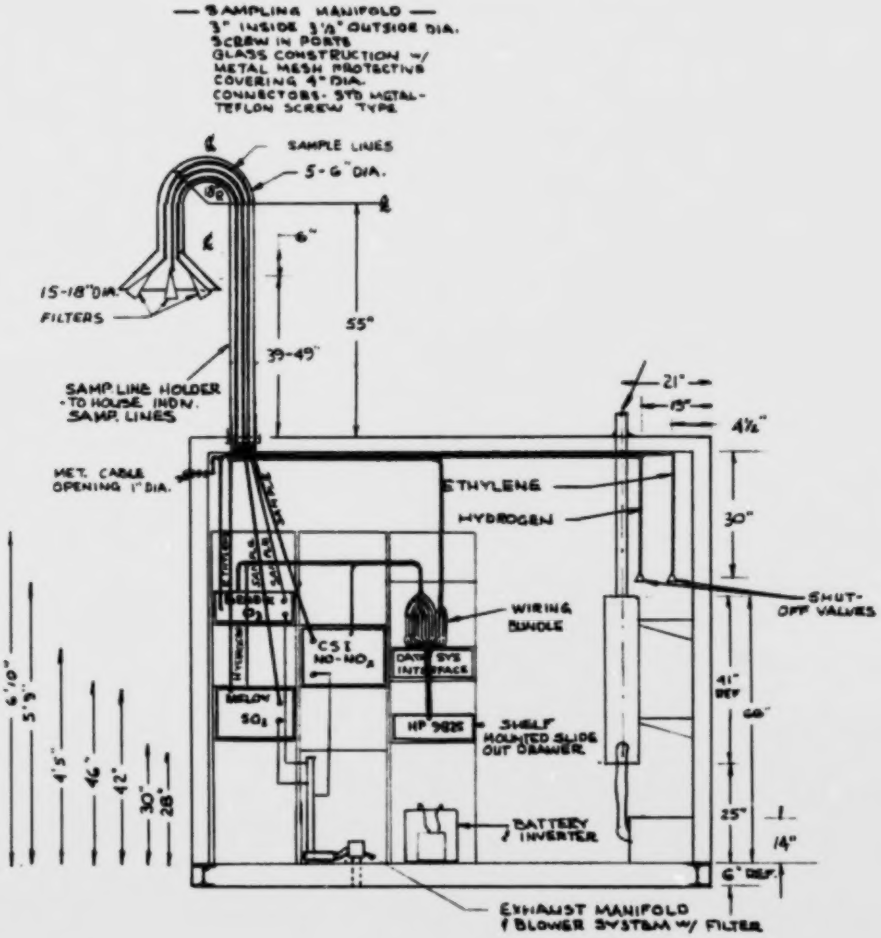
— SAMPLING MANIFOLD —
3" INSIDE 3½" OUTSIDE DIA.
SCREW IN PORTS
GLASS CONSTRUCTION W/
METAL MESH PROTECTIVE
COVERING 4" DIA.
CONNECTORS- STD METAL-
TEFLON SCREW TYPE
SAMPLE LINES
5-6" DIA.
15-18" DIA.
FILTERS
6"
55"
39-49"
SAMP. LINE HOLDER
-TO HOUSE INDV.
SAMP. LINES
MET. CABLE
OPENING 1" DIA.
ETHYLENE
HYDROGEN
21"
15"
4½"
30"
SHUT-
OFF VALVES
WIRING
BUNDLE
CSI
NO-NO$_x$
DATA SYS
INTERFACE
SO$_2$
HP 9825
SHELF
MOUNTED SLIDE
OUT DRAWER
41" REF
68"
25"
14"
6" REF.
BATTERY
& INVERTER
EXHAUST MANIFOLD
& BLOWER SYSTEM W/ FILTER
6'10"
5'9"
4'5"
46"
42"
30"
28"

Figure 2. Ohio River Valley air-monitoring station front view.

BEGIN FIRST LINE OF TEXT HERE
TOP OF IMAGE AREA
DROPPED HEAD BEGIN SECTIONS HERE

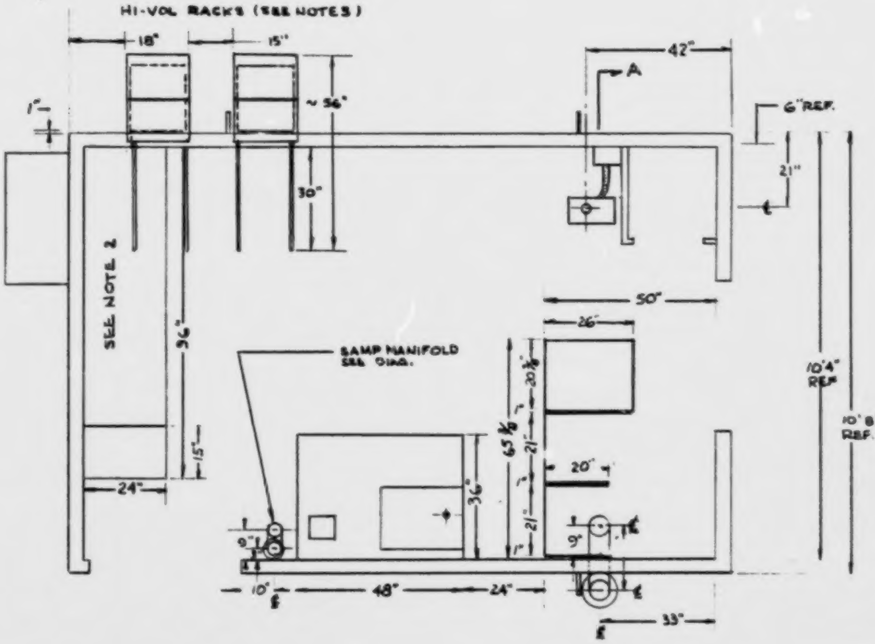
HI-VOL RACKS (SEE NOTES)
18"
15"
~ 56"
1"
30"
SEE NOTE 2
36"
15"
24"
42"
A
6" REF.
21"
℄
50"
26"
SAMP MANIFOLD SEE DIAG.
20 1/2"
1"
65 3/4
21"
20"
36"
1"
21"
1"
9"
9"
℄
10'4" REF.
10'8" REF.
10"
48"
24"
℄
33"

Figure 3. Ohio River Valley air-monitoring station equipment layout--floor plan.

BEGIN LAST LINE OF TEXT
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PAGE NUMBER
EPA Form 2290-4 (4-80)
TYPING GUIDE SHEET

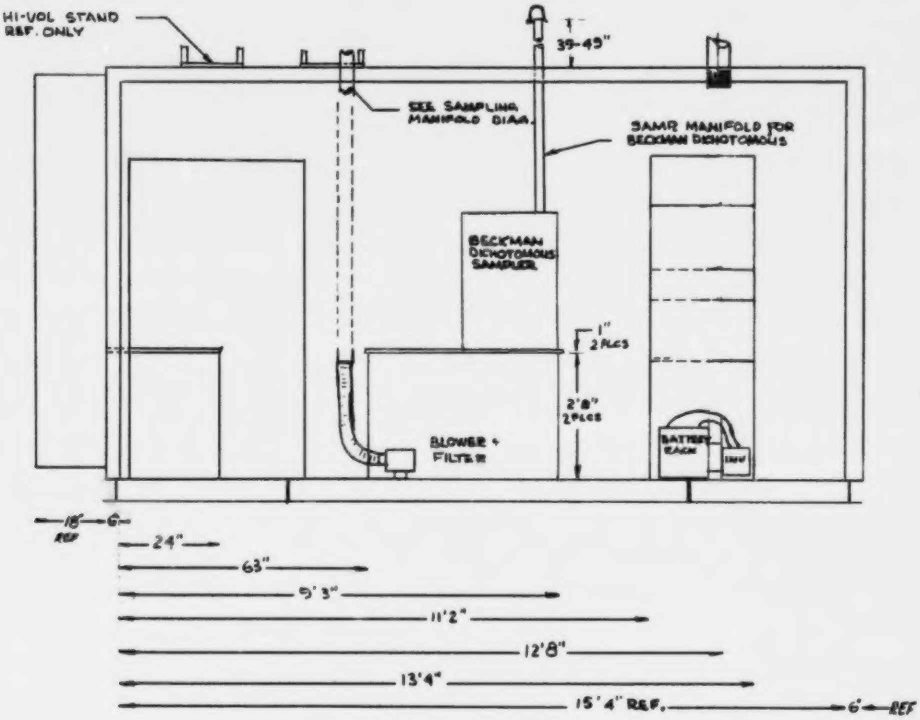
HI-VOL STAND
REF. ONLY
39-49"
SEE SAMPLING
MANIFOLD DIAG.
SAMR MANIFOLD FOR
BECKMAN DICHOTOMOUS
BECKMAN
DICHOTOMOUS
SAMPLER
1"
2 PLCS
2'8"
2 PLCS
BLOWER +
FILTER
BATTERY
RACK
INV
18
REF
6
24"
63"
9'3"
11'2"
12'8"
13'4"
15'4" REF.
6'
REF

Figure 4. Ohio River Valley air-monitoring station side view.

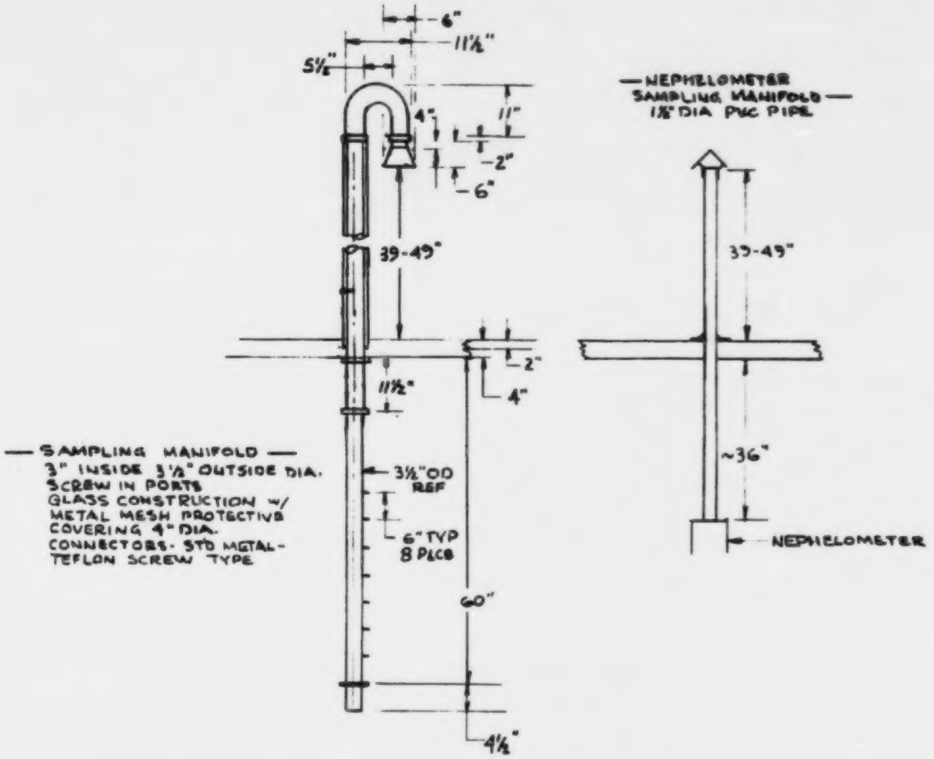
6"
11½"
5½"
4"
11"
2"
6"
39-49"
2"
11½"
4"
— SAMPLING MANIFOLD —
3" INSIDE 3½" OUTSIDE DIA.
SCREW IN PORTS
GLASS CONSTRUCTION w/
METAL MESH PROTECTIVE
COVERING 4" DIA.
CONNECTORS- STD METAL-
TEFLON SCREW TYPE
3½" OD REF
6" TYP 8 PLCS
60"
4½"
— NEPHELOMETER
SAMPLING MANIFOLD —
1⅜" DIA PVC PIPE
39-49"
~36"
NEPHELOMETER

Figure 5. Ohio River Valley air-monitoring station sampling manifolds.

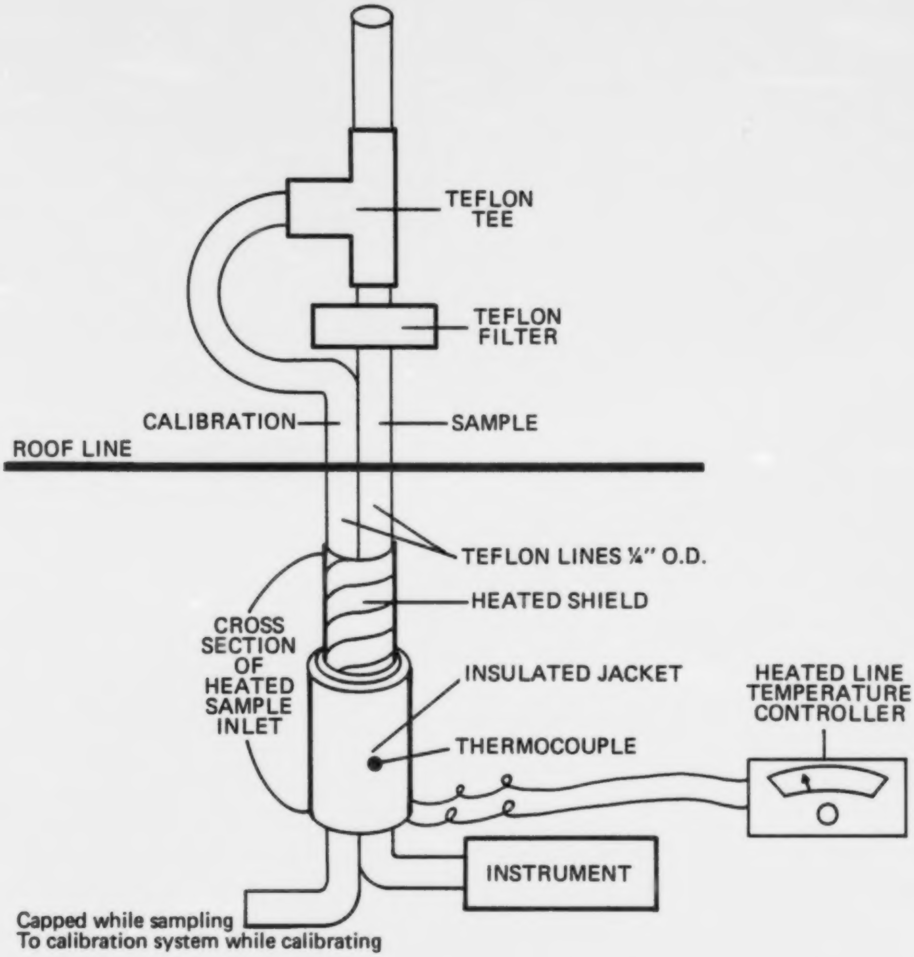
TEFLON TEE
TEFLON FILTER
CALIBRATION
SAMPLE
ROOF LINE
TEFLON LINES ¼" O.D.
HEATED SHIELD
CROSS SECTION OF HEATED SAMPLE INLET
INSULATED JACKET
HEATED LINE TEMPERATURE CONTROLLER
THERMOCOUPLE
INSTRUMENT
Capped while sampling
To calibration system while calibrating

Figure 6. Heated sample inlet system.

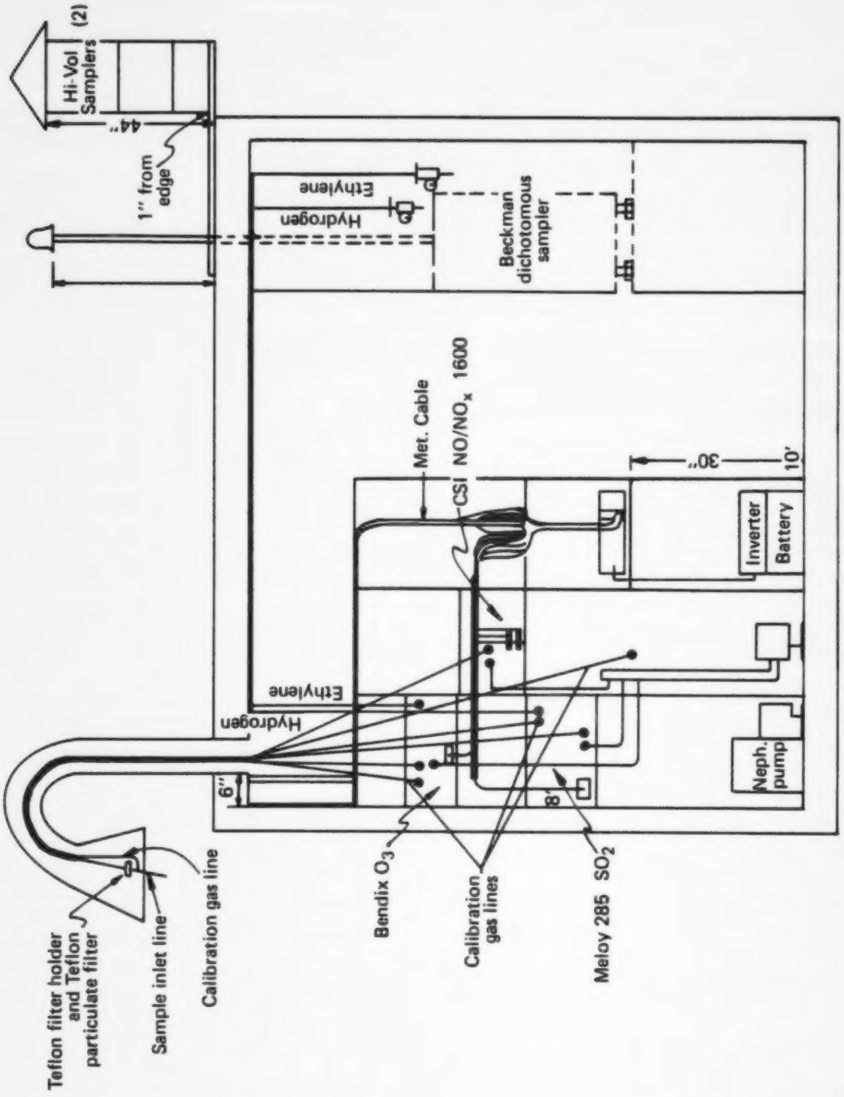
Teflon filter holder and Teflon particulate filter
Sample inlet line
Calibration gas line
Bendix O_3
Calibration gas lines
Meloy 285 SO_2
6"
8'
Neph. pump
Hydrogen
Ethylene
CSI NO/NO_x 1600
Met. Cable
Inverter
Battery
30"
10'
Beckman dichotomous sampler
Hydrogen
Ethylene
1" from edge
44"
Hi-Vol Samplers (2)

Figure 7. Inlet system for gaseous analyzers: only one in-line particulate filter with attached sample and calibration lines is shown.

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which maintains the line temperature at 100°F (38°C), well above the highest anticipated ambient sampling dewpoint, ensuring that no condensation and attendant sample degradation can occur.

The heated line sheath passes inside a 3-in. ID glass Kimax Process pipe and down through the shelter roof. Just inside the roof, each pair of sample and calibration lines is enclosed in a separate heated sheath leading to each analyzer. Inside the station, the 0.25-in. inlet line for sampling is connected to the instrument, and the calibration line is capped. Outside the station, the calibration line is connected to a Teflon tee (see Figure 6). The sample line is connected to a Teflon in-line filter, which in turn is connected to the same tee. The third branch of the tee is open to the atmosphere for sampling purposes or serves as a vent for excess calibration gas. This arrangement allows calibration gas to pass through the entire ambient sample inlet system. The Teflon filter prevents accumulation of dust and particulates in the sample line.

(4) The high-volume sampler was located as far from the gaseous analyzer and dichotomous sampler inlets as possible and was suspended over the edge of the shelter roof on mounting brackets so that its exhaust would be deflected down the shelter wall and away from the other inlets (see Figure 2).

(5) The inlet system for the dichotomous sampler is shown in Figure 8. A means of disconnecting the inlet just above the sampler is necessary for performing flow rate checks. Previous couplers caused metallic particle

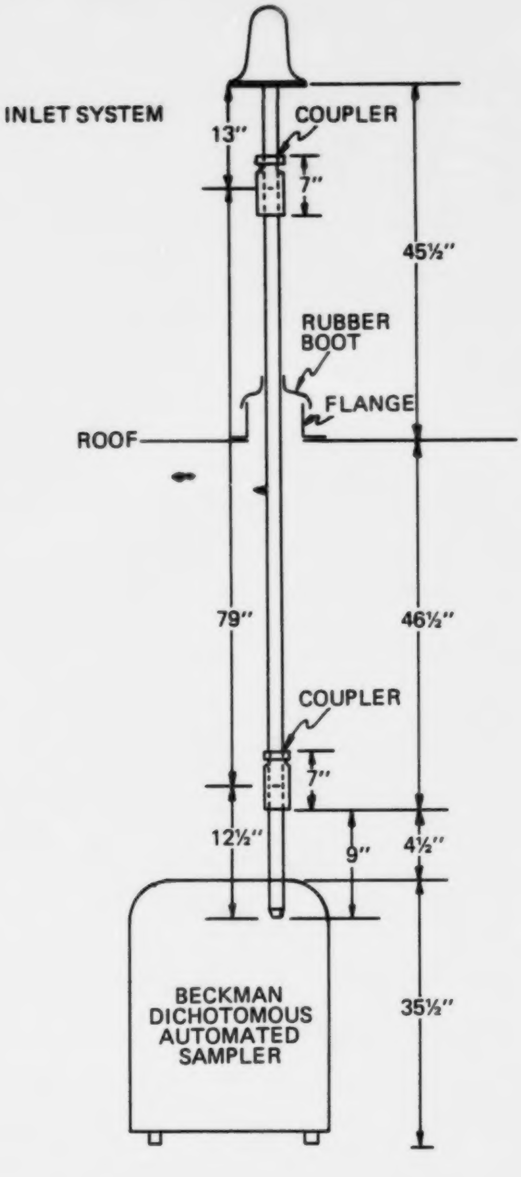
INLET SYSTEM
COUPLER
13"
7"
45½"
RUBBER BOOT
FLANGE
ROOF
79"
46½"
COUPLER
7"
12½"
9"
4½"
BECKMAN DICHOTOMOUS AUTOMATED SAMPLER
35½"

Figure 8. Inlet system for dichotomous sampler.

contamination or leaked. The NSI coupler, shown in Figure 9, is nonmetallic and sufficiently rigid to securely hold the upper and lower portions of the inlet in alignment.

The rubber boot and flange located on the station roof (see Figures 8 and 10) allow the inlet to be readily lifted out of the lower coupler. The boot also adjusts for deviation of the inlet from perpendicular due to irregularities in the station floor or maladjustment of the dichotomous sampler leveling feet. This allows the sampler to be moved for maintenance or repair and replaced without requiring re-leveling. The dichotomous sampler inlet-coupler system was designed by Paul Killough, of the NSI machine shop.

(6) To reduce or eliminate the effects of line voltage fluctuations on instrument responses, the A.C. power to the instrument racks is regulated by a Sola CVS23-25-230-3 constant voltage transformer to within ± 0.5%, for an input range of ± 15% of nominal voltage.

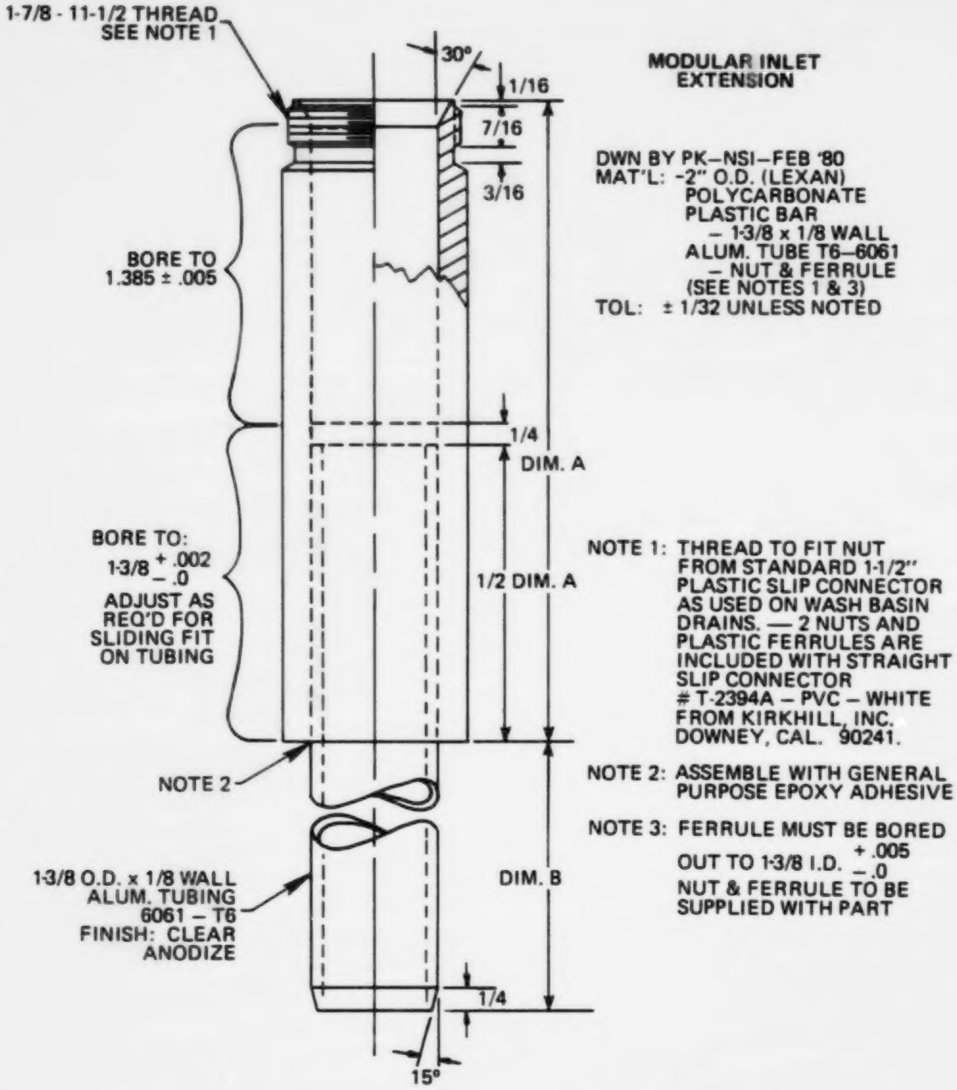
1-7/8 - 11-1/2 THREAD
SEE NOTE 1
30°
1/16
7/16
3/16
MODULAR INLET
EXTENSION
DWN BY PK–NSI–FEB '80
MAT'L: -2" O.D. (LEXAN)
POLYCARBONATE
PLASTIC BAR
– 1-3/8 x 1/8 WALL
ALUM. TUBE T6–6061
– NUT & FERRULE
(SEE NOTES 1 & 3)
TOL: ± 1/32 UNLESS NOTED
BORE TO
1.385 ± .005
1/4
DIM. A
BORE TO:
1-3/8 + .002 – .0
ADJUST AS
REQ'D FOR
SLIDING FIT
ON TUBING
1/2 DIM. A
NOTE 1: THREAD TO FIT NUT FROM STANDARD 1-1/2" PLASTIC SLIP CONNECTOR AS USED ON WASH BASIN DRAINS. — 2 NUTS AND PLASTIC FERRULES ARE INCLUDED WITH STRAIGHT SLIP CONNECTOR # T-2394A – PVC – WHITE FROM KIRKHILL, INC. DOWNEY, CAL. 90241.
NOTE 2
NOTE 2: ASSEMBLE WITH GENERAL PURPOSE EPOXY ADHESIVE
NOTE 3: FERRULE MUST BE BORED OUT TO 1-3/8 I.D. + .005 – .0 NUT & FERRULE TO BE SUPPLIED WITH PART
1-3/8 O.D. x 1/8 WALL
ALUM. TUBING
6061 – T6
FINISH: CLEAR
ANODIZE
DIM. B
1/4
15°

Figure 9. Disconnector-coupler for dichotomous sampler inlet.

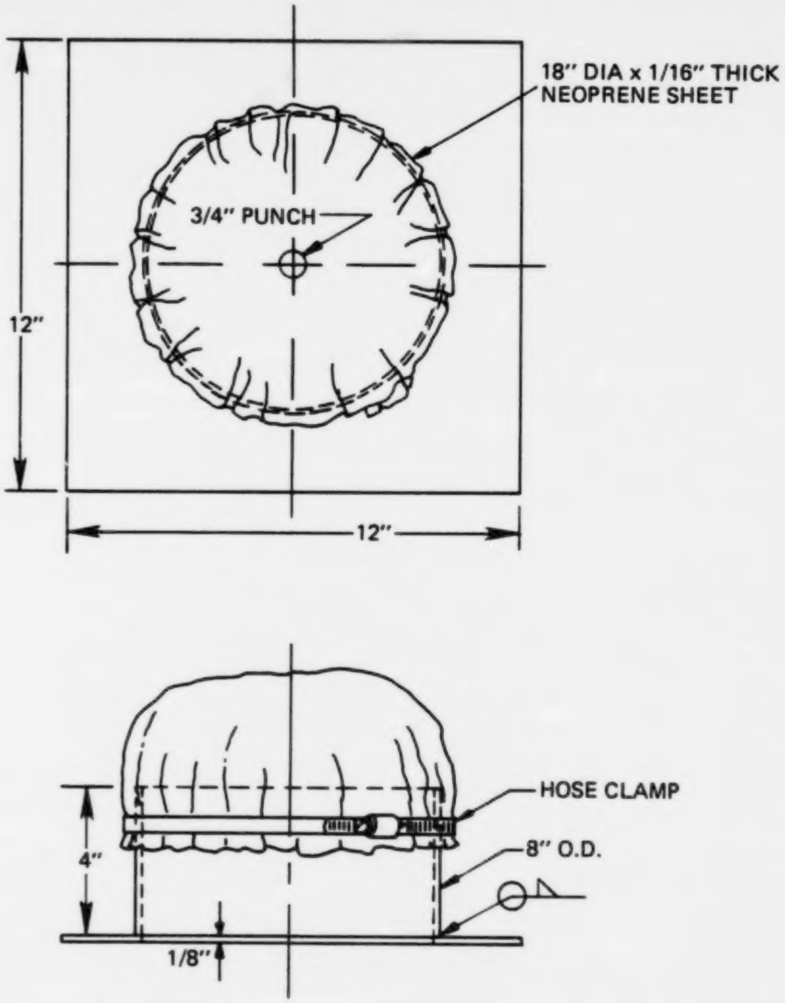
18" DIA x 1/16" THICK
NEOPRENE SHEET
3/4" PUNCH
12"
12"
HOSE CLAMP
8" O.D.
4"
1/8"

Figure 10. Rubber boot and flange.

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SECTION 3

OPERATIONAL TESTING OF AIR-MONITORING STATIONS

The objectives of the ORV station testing program were to demonstrate that all systems were reliable, that the data acquisition and recording system was error-free, and that the data tapes produced could be read and decoded. Additional tests performed were comparisons of heated sample lines to verify reliable performance, evaluation of the air conditioning system, and stability and accuracy testing of the data acquisition system. All of these functions and the performance of the continuous analyzers were verified by operating one station for fifteen days and the other two for seven days each.

ACCURACY AND STABILITY TESTING OF DATA ACQUISITION SYSTEM

To test the accuracy of the data acquisition system, selected voltages were provided by a stable regulated source, and the system was monitored with a Data Precision digital voltmeter. Voltages of 3.950, 2.000, 1.000, 0.500, and 0.100 were provided to the system for five minutes each. For all three data acquisition systems, the Eastchester device and the HP9825A typically agreed with the digital voltmeter within -0.001 v, with a maximum difference of -0.002 v. To evaluate the stability of this design, 1-v and 0.1-v inputs were provided to the system on February 25 through 26 and 26 through 27,

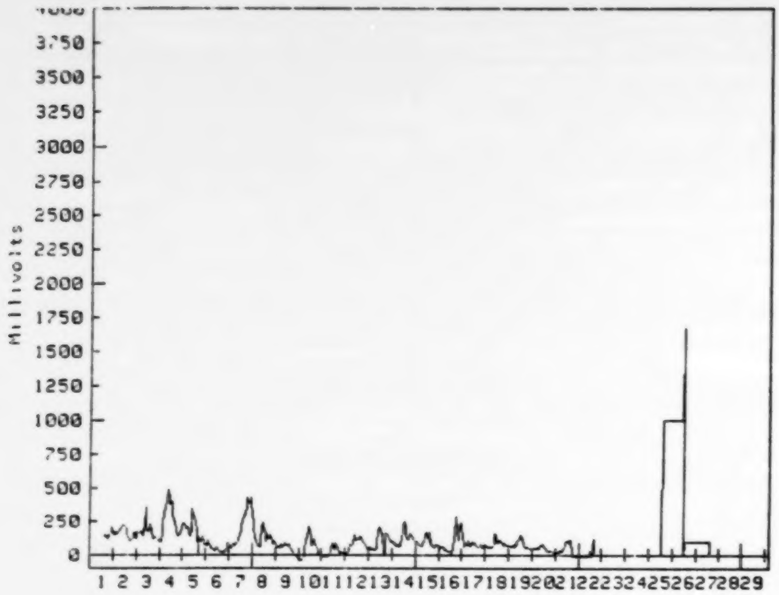

Figure 11. Data acquisition system stability test results. Feb. 25-26: 1-v input; Feb. 26-27: 0.1-v input.

respectively, as indicated in Figure 11. The results shown in Figure 11 indicate no erratic data collection by the data acquisition system. One-minute readings and hourly averages gave valves from +0 to -0.002 mv of the input voltage.

DATA ACQUISITION SOFTWARE MODIFICATIONS

Several problems with the data acquisition system were solved by software modifications. Whenever the sampled signal from an instrument exceeded 4 v

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(the maximum allowable input signal), the over-range bit would be interpreted as 8.0 and recorded for that minute; this resulted in some erroneous hourly averages in the December and January data. This problem was corrected through the addition of the following program statement: if signal (x) is greater than 4 v then signal (x) is equal to 4 v.

The data acquisition system and software as orginally provided sampled the analog signal for each channel ten times in a given minute, summed the binary coded decimal (BCD) values, and divided by ten to obtain an average BCD signal, which was then converted to binary and stored as the signal value for that minute. However, there apparently were occasions when fewer than ten samples were obtained, but the summed BCD values were nonetheless divided by ten. This was most apparent when the signals obtained were near-zero negative values: BCD values of -2 or -3 v resulted from summing fewer than ten samples and dividing the sum by ten. As a result of this problem, some of the hourly averages in the December and January data were depressed. The problem was solved by the following programming technique: first, the signal is sampled twice, and the two samples are compared; if the ratio of two samples is greater than 1.1 or less than 0.9, this process is repeated; if the ratio of two samples falls within this range, the sample BCD values are converted to binary. The foregoing procedure is repeated until ten binary samples are obtained; these are summed, this sum is divided by ten, and this value is stored as the signal value for that minute.

HEATED LINE SAMPLE TESTS

Measured concentrations of NO_2, SO_2, and O_3 were sampled through lines of various lengths heated to approximately 100°F (38°C) and 110°F (43°C). Little or no difference was found among the concentrations measured for sample line lengths of two, five, and ten feet. The results of these tests are given in Table 1. No distinguishable difference in conditioning time or time for analyzer-sample line equilibration for ozone and oxides of nitrogen was observed. Tests conducted using SO_2 indicated a conditioning time of approximately 20 min to achieve span point equilibrium (100 ppb range). Step level decreases in concentration equilibrated in about 5 min.

TABLE 1. COMPARISONS OF POLLUTANT CONCENTRATIONS SAMPLED THROUGH LINES OF THREE DIFFERENT LENGTHS, AT TWO TEMPERATURES

Pollutant	Temperature	2-ft line (ppm)	5-ft line (ppm)	10-ft line (ppm)	% Difference
NO_2	110°F (43°C)	0.556		0.559	0.5
		0.353		0.355	0.6
		0.198		0.197	-0.5
		0.106		0.105	-0.9
		0.076		0.075	-1.3
		0.055		0.056	1.8
SO_2	100°F (43°C)	0.256		0.250	-2.3
		0.195		0.194	-0.5
		0.135		0.136	0.7
		0.075		0.075	0
		0.046		0.043	-6.5
		0.020		0.019	-5.0

(continued)

TABLE 1 (continued)

Pollutant	Temperature	2-ft line (ppm)	5-ft line (ppm)	10-ft line (ppm)	% Difference
O_3	100°F	0.372		0.361	-3.0
	(38°C)	0.267		0.255	-4.5
		0.208		0.202	-2.8
		0.146		0.146	0
		0.084		0.085	1.2
O_3	100°F	0.366		0.366	0
	(38°C)	0.260		0.259	-0.4
		0.203		0.202	-0.5
		0.144		0.143	-0.7
		0.083		0.083	0
		0.059		0.059	0
O_3	100°F	0.365		0.370	1.4
	(38°C)	0.259		0.260	0.4
		0.202		0.199	-1.5
		0.142		0.141	-0.7
		0.082		0.080	-2.4
		0.060		0.057	-5.0
NO_2	100°F	0.326	0.325		-0.3
	(38°C)	0.234	0.235		0.4
		0.103	0.105		1.9
		0.053	0.051		-3.8
O_3	100°F	0.319	0.315		-1.3
	(38°C)	0.218	0.215		-1.4
		0.074	0.075		1.4
		0.042	0.042		0
SO_2	100°F	0.254	0.251		-1.2
	(38°C)	0.050	0.047		-6.0
		0.022	0.022		0
		0.008	0.008		0

AIR CONDITIONING EVALUATION

The air conditioning systems of the stations were evaluated in January and February. A maximum-minimum-indicating thermometer was placed on a desk below the air-conditioning duct. The difference between the maximum and minimum temperatures for any 24-h period was typically 2°F (1°C) and did not exceed 4°F (2°C).

ORV STATION INSTRUMENT FAILURES

NSI began operational testing of the reliability of the continuous analyzers (NO_x, SO_2, and O_3) in September, 1979. Data for the ORV station failures are given in Tables 2 through 5. Failure of the Columbia Scientific NO_x analyzers was so frequent that continuous data could not be reliably obtained. The primary problems were separating of ribbon cable connectors and sticking of the motor valve. The motor valve directs sample flow either through the converter or directly to the reaction chamber for NO_x or NO analysis.

The Bendix O_3 monitors had no failures. The Meloy sulfur analyzers leaked around fittings on the burner block: rubber seals around fittings, such as the thermocouples and igniter, leaked if the analyzers were turned off long enough to completely cool down.

TABLE 2. CSI NO_x ANALYZER FAILURES

Serial No.	Date Occurred	Date Corrected	Problem	Solution
9707	790822	790822	motor valve stuck	cleaned ultrasonically
	790823	790827	B^+ connector intermittent	
	790910	790917	loose jumper on meterboard	reinserted connector
	790919	790919	excessive span drift	realigned electronics; recalibrated
	790919	790925	offset between NO and NO_x not adjustable	called CSI service rep., who ordered new motor valve and sample air capillary
	791001	791102		moved NO_x from 062103 to 062042; installed new motor valve; glued all connectors in place
	791205			moved NO_x from 062042 to 062103
	800123	800123	cooler failed	replaced output transistor
9710	790925	--	pump leaked; PM tube bad; bad connector	returned to CSI for NO_x 9894
9711	790911	--	connector problems; bad PM tube	returned to CSI for NO_x 9895

(continued)

TABLE 2 (continued)

Serial No.	Date Occurred	Date Corrected	Problem	Solution
9894	791015	--	NO_x channel suddenly went full scale intermittently	(no repair made)
	791115	791121	motor valve stuck	installed new valve
	791121	791129	NO_x pegged full scale	installed filter storage board
	791130	791212	motor valve stuck	returned to CSI for service; installed in 062042
	791219	791220	motor valve stuck	sprayed with contact cleaner
9895	791101	791221	PM tube output low, not adjustable	returned to CSI for repair

The nephelometer light source burned out frequently. Lamp lifetimes were considerably lengthened by turning down the lamp voltage and using a Sylvania DNF lamp. The Brookville station (062103) nephelometer had a single electronic failure caused by leaking rainwater.

The Beckman dichotomous samplers had occasional alignment problems, but were operating reliably when turned over to the station-operating contractor.

TABLE 3. MELOY SO_2 ANALYZER FAILURES

Serial No.	Date Occurred	Date Corrected	Problem	Solution
5L042	790918	790918	insufficient response	coarse setting for PMT high voltage adjusted; recalibrated
	791115	791115	nonlinear	electronic alignment
	791129	791130	span set near minimum; responded, but noisy	located H_2 leak and tightened fitting
8K081	791102	791114	igniter not working	replaced
	791119	791122	poor response	located leaking fitting
	791211	791211	nonlinear; poor response	checked for leaks; realigned
8L049	790914	790928	nonlinear	realigned
	791031	791126	glow plug burned out	replaced
	791128	791129	nonlinear	realigned
	800103	800103	inadequate response	leak at thermocouple tightened

TABLE 4. INTEGRATING NEPHELOMETER FAILURES

Serial No.	Date Occurred	Date Corrected	Problem	Solution
114	791023	791023	loose connector	reconnected
115	791119	791204	lamp burned out	replaced
	791204	791212	electronic calibrate mode not working	disassembled and cleaned
116	791119	791128	lamp burned out	replaced
	791214	791214	electronic calibrate mode offscale	cleaned spot from window
	791227	791228	lamp burned out	replaced

OPERATIONAL TESTING OF CONTINUOUS ANALYZERS

To verify that the ORV stations were performing to the design standards, one station was operated for fifteen days and the other two for seven days. Calibration and audit data obtained during the operational testing are given in Appendix A, Tables A-1 through A-12.

Plots of the data decoded from tapes obtained during the operational tests are also given in Appendix A, Figures A-1 through A-18. All station systems operated reliably during the fifteen- and seven-day tests. Missing records due to operator interruptions are explained below each data plot.

TABLE 5. MISCELLANEOUS FAILURES OF STATION SYSTEMS

System (identification)	Date Occurred	Date Corrected	Problem	Solution
NSI calibration system	790910	790914	mass flow controller sensor clogged	cleaned and recalibrated
Aadco clean air system	790917	790917	excessive moisture in ballast tank	added cooling coil and bled vent at lowest point of coil
NSI calibration system	790919	790919	excessive O_3 output	installed adjustable shield
Air conditioner (062103)	791001	791009	burned up switch	
NSI calibration system	791010	791016	flowmeters reading incorrectly	repaired and aligned several Tylan FM-400 flowmeters
Heated lines	791022	800110	thermocouples shorted, overheating lines	redesigned and purchased new line
NSI calibration system	791024	791024	leak	replaced line
Strip chart recorder	791116	791116	not inking	replaced inkline
Digital voltmeter	791120	791129	open line in charger cord	replaced charger linecord
Strip chart recorder	791211	791211	noisy	Aadco clean air system powerline moved to another circuit
Inverter	800107		no output	returned to factory

SECTION 4

TRAINING OF STATION-OPERATING PERSONNEL

The objectives of the training sessions conducted by NSI were as follows:

(1) Inform the station-operating personnel of the purpose of the ORV program and present the sample analysis and data processing facilities to them.

(2) Familiarize station-operating personnel with the station configuration (location of instruments and sample ports, startup and shutdown procedures, electrical supply, and air conditioning system).

(3) Briefly discuss each instrument and critical points of operation.

(4) Give each operator individual experience in alignment and minor troubleshooting for each instrument.

(5) Train each operator to properly operate and maintain the data acquisition system.

The training of the ORV station-operating personnel took place over a three-day period. On the first day, the operating personnel were given a tour of the Environmental Sciences Research Laboratory Inorganic Pollutants Analysis Branch and Organic Pollutants Analysis Branch laboratories and computing facilities, to familiarize them with the data analysis techniques to be used on the stations' samples. They were introduced to the EPA Technical Monitor, who explained in greater detail the goals of the ORV monitoring effort. The operating personnel were then taken to one of the air-monitoring stations. The station configuration and the locations of the instruments, sample inlets, electrical supply, circuit breakers, air-conditioning controls, cylinder storage, and other features were explained. A brief discussion was given of each instrument, its principle of operation, its required routine maintenance, and the uses of its data.

On the second day, the operating personnel practiced aligning and adjusting each instrument. The most frequent problems and their solutions for each instrument were discussed. For example, changing the motor valve in the Columbia Scientific NO_x analyzer and leak-checking the Meloy sulfur analyzer both were demonstrated.

Operation of the data acquisition system was explained on the third day. Each operator had the opportunity to practice operating the data acquisition system, including turning the system on, loading the program, marking a data tape, isolating an instrument being calibrated or down for repairs, and wiring in analog signals from analyzers. The operators were then given keys and free access to the stations in order to perform acceptance testing and to gain experience in operating the stations on a daily basis, while technical assistance was available if needed.

SECTION 5

DATA ACQUISITION SYSTEM

DESCRIPTION OF SYSTEM

The components of the data acquisition system are shown in block form in Figure 12. The HP9825A is a desk-top programmable calculator with 6844 bytes of read/write memory, a 32-character LED display, a 16-character strip printer, and a built-in two-track tape cartridge drive. The ORV installation also includes a 98213A General I/O-Extended I/O Read Only Memory (ROM), a real-time clock, and a 98032A 16-bit I/O interface. The calculator uses HPL, a high-level language designed for scientific and engineering applications. The power required is 120 v, 180 w.

The analyzers and meteorological sensors are interfaced to the HP9825A by an Eastchester Corp. interface. The Eastchester interface is essentially a digital voltmeter (DVM) with a binary output and a multiplexer controlled by the HP9825A. Each minute, the calculator commands the multiplexer to sample the 16 input channels. The analog voltage is converted to binary coded decimal (BCD) by the DVM. The calculator reads the BCD output from the DVM and then commands the multiplexing section to sample the next channel. Thus, the DVM display is always one channel ahead of the value in the HP9825A display. The BCD value is input to the HP9825A, where it is converted by the

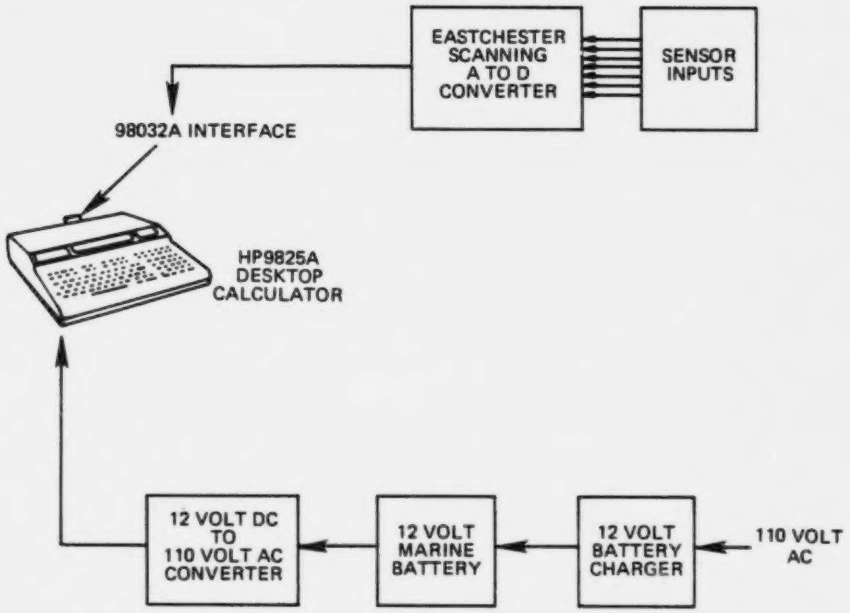
EASTCHESTER SCANNING A TO D CONVERTER
SENSOR INPUTS
98032A INTERFACE
HP9825A DESKTOP CALCULATOR
12 VOLT DC TO 110 VOLT AC CONVERTER
12 VOLT MARINE BATTERY
12 VOLT BATTERY CHARGER
110 VOLT AC

Figure 12. Block diagram of data acquisition system.

software to a binary value. This value is presented in the HP9825A display for each channel.

The one-minute readings are summed for one hour. At the end of the hour, an hourly average is calculated and printed on the HP9825A's onboard printer along with the time and date on which the data were taken. The values are also recorded on the data cassette.

The pin description for the analog input connector to the Eastchester interface is shown in Table 6. Channels are assigned as follows:

(1) NO
(2) NO_x
(3) NO_2
(4) S (total sulfur)
(5) O_3
(6) nephelometer
(7) wind speed
(8) wind direction
(9) temperature
(10) dewpoint
(11) solar radiation
(12) barometric pressure
(13-16) unassigned

TABLE 6. ANALOG INPUT CONNECTOR PIN DESCRIPTION

Channel Number	High Color	Low Color	High Pin	Low Pin
1	blue	gray	6	8
2	yellow	red	4	2
3	orange	brown	3	1
4	green	violet	5	7
5	white/black/yellow	white/black/blue	26	28
6	white/black/red	white/gray	24	22
7	white/black/brown	white/violet	23	21
8	white/black/orange	white/black/green	25	27
9	white/brown/red	white/black/violet	31	29
10	white/brown/yellow	white/brown/blue	33	35
11	white/brown/green	white/brown/violet	34	36
12			30	32
13	white/brown	white	11	9
14	white/orange	white/green	13	15
15	white/yellow	white/blue	14	16
16	white/red	white/black	12	10

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OPERATING INSTRUCTIONS

These operating instructions are based on the assumption that the data acquisition system has been installed as described on p. 14 of the ORBS Station Operation Manual (Appendix B, p. B-20).

Insert a fresh data tape into the calculator transport. This tape should have the program recorded in file 0 and the special function keys in file 1 on both tracks 0 and 1. Turn on the Eastchester interface. Turn on the HP9825A calculator. The system will automatically load the software and begin taking data. Once per hour, the one-minute readings are averaged and the average printed and recorded on magnetic tape. These operations should be verified by observing the printer at the end of the hour and by observing the small yellow light to the lower left of the data cassette. The light should come on briefly, and one can hear the tape drive running as the hourly averages are recorded. Also verify that the time, date, and station identification number are correct.

To set the time and date, use the following procedure:

(1) Press the "stop" button.
(2) Type in: WRT 9, "S MO, DA, HR, MN, SC".
(3) Press the "execute" button; wait 15 seconds.
(4) Press the "run" button.

There are two methods of isolating the channel of an instrument to be calibrated or down for repairs. One is to disconnect the leads for that channel and apply to them a voltage of less than -1 v (typically, a D-cell flashlight battery). The second method is to use the special-function key to call a routine that allows a channel to be isolated by the program. Six channels can be isolated. The HP9825A will display a variable name L, M, N, O, P, or Q. The operator must type in a channel number for each variable name being assigned to a channel and zero for each variable name not being assigned to a channel. To isolate a channel by this method, use the following procedure:

(1) Press the "stop" button.

(2) Press the "cal" button, and wait until the end of the current minute, when the calculator prints "CAL CHNLS, L?".

(3) Type in the number of the first channel to be isolated (start with the lowest number).

(4) Press the "continue" button.

(5) When the calculator prints "M?", type in the number of the next channel to be isolated (the second-lowest number).

(6) Continue as above for additional channels to be isolated, entering channels in ascending numerical order (up to six channels). If fewer than six channels are to be isolated, enter a zero for each of the variable names that will not be assigned to a channel (through variable Q).

The system will automatically begin taking data after all six of the calibration channel variables have been defined as a number (from 1 to 16 or 0).

To end a calibration or return all six calibration variables (L-Q) to zero and begin taking data on all channels, use the following procedure:

(1) Press the "stop" button.

(2) Press f_1.

The internal printer will print all six of the calibration variables and the channel assigned by the operator to each variable.

If the operator stops the acquisition of data by pressing the "stop" button (for some reason other than to enter calibration channels), restarting the system by pressing the "run" button will reset all variables to zero. This means that all data acquired from the beginning of that hour until the time the operator pressed the "run" button will be lost. The "operator event" key, f_2, can be used to restart the system without the loss of any data other than that missed while the system was stopped. To restart the system with the "operator event" key, simply press "f_2", and the system will automatically restart.

To insert the correct year and station identification number, use the following procedure:

(1) Press the "stop" button.

(2) Press the "fetch" button.

(3) Type in "13".

(4) Press the "execute" button.

(5) Line 13 should be displayed as follows: WRT 9, "R"; 800 000 0000 → K; (station ID no.) → D{1}; FXD 2.

(6) Press the "FWD" button to move the cursor over the "8", and type in the year.

(7) Advance the cursor to the station ID section and type in the station ID number.

(8) Press the "store" button.

(9) Type in "TRK 0".

(10) Press the "execute" button.

(11) Type in "RCF 0".

(12) Press the "execute" button.

(13) Type in "TRK 1".

(14) Press the "execute" button.

(15) Type in "RCF 0".

(16) Press the "execute" button.

SUMMARY OF SOFTWARE

The first five lines of the HP9825A program direct allocation of memory space for data storage. Lines 6 through 12 direct calculation of the hourly average wind direction. Lines 13 through 17 direct the calculator to read time from the real time clock and check for the end of the minute, to command channel scans. Lines 19 through 46 direct the scanning of all 16 channels, the isolation (an operator command) of channels for instruments that are being calibrated or are otherwise offline, and the conversion of BCD values to binary. Lines 47 through 50 direct the calculator to display the channels and check for the end of the hour. At the end of the hour, lines 51 through 83 direct calculation of the track and file number and the hourly averages, recording of hourly data on magnetic tape, and printing of hourly averages on the internal printer.

Special function keys f_0, f_1, and f_2 are operator control keys with which to command isolation of channels for instruments being calibrated, return isolated channels to data acquisition, and restart data acquisition after it is interrupted by the operator (the "operator event" key).

LINE-BY-LINE DESCRIPTION OF SOFTWARE

Line No.	Description
0	Loads special function keys in file 1.
1	Allocates memory space for array variables, A{*} = no. of hourly scans, B{*}= sum of one-minute scans, C{*} = average data = $\frac{B\{*\}}{A\{*\}}$.
2	Checks to see if wind-speed correction factors are entered.
3	Counter is incremented when autoload occurs or "run" button is used to start program.
4	Assigns wind-speed calculation to channel 7.
5	Bypasses wind-direction subroutine.
6	Calculates wind bearing factor.
8-11	Calculates quadrant.
12	Using data from steps 7-11, calculates average wind direction; returns to line 64 (see average wind direction procedure, Table 7 and Figure 14).
13	WRT 9, "R"; real time request; 800 000 0000 → K; sets year (1980); __________ → D{1} is station ID no. to be inserted by operator.

Line No.	Description
14	Reads time A = month, B = day, C = hour, D = minute, E = seconds.
15	Displays time.
16	Checks to see if one minute has passed.
17	Sets up end-of-minute check and end-of-hour check; loops from 13 to 16 until one minute passes.
18	Sends new minute to F; initializes J.
19	Loops to read 16 data channels.
20	See line 4, WTB 2, J; selects data channel to be read.
21	Sets up loop to read each channel 10 times and averages the result.
22	Reads BCD from Eastchester unit (device 2) channel J; stores value in X.
23	Repeats line 22, but stores value in Y.
24	Prevents halt of execution in line 25 if Y = O.
25	Compares X and Y; verifies that readings are not the results of noise or transient signals.
26	See line 24.
27	Sets up loop to convert BCD to binary.
28-31	Loop to convert BCD to binary.
32	Sums value of X in U 10 times.
33	Generates average value of X.
34	If Z = 9, requests calibration channels; if J = L, M, N, O, P, or Q, skips summation.
35-40	Passes data from calibration channels around line 46 (which sums the one-minute scans).
41	Limits maximum value of input to 4 v.
42	Alternate method of isolating channel to be calibrated or from down instrument.

Line No.	Description
43	If input is not wind direction channel, bypasses lines 44 and 45.
44	Sends program execution to line 79, "trig 1".
45	Returns from subroutine "trig 1" and skips line 46.
46	Sums one-minute readings in B{*}; counts number of one-minute scans taken in A{*}.
47-48	Displays channel and voltage just read.
49	Goes to next channel.
50	If C = G, checks for end of hour.
51	Date goes to D{2}.
52	Resets end-of-hour check; calculates file number.
53	Calculates track (0 or 1).
54	Calculates track (0 or 1).
55	Selects track command.
56	Sets up error routine if line 57 error is printer out of paper (error no. 15).
57	If error no. not equal to 15, formats, then writes, as per format specification, track and file numbers.
58	If error 15 in line 57, continues execution at line 59.
59	Initializes counter I.
60	Sets up loop to calculate hourly average for each of 16 channels.
61	Bypasses wind-direction data whose average has already been calculated in "trig 1".
62	Checks to see if wind-speed channel 45 = 7; if I = 7, goes to 65.
63	If channel = 7, sends execution back to "trig 1".
64	Goes to 66.

Line No.	Description
65	Calculates hourly average C{*}.
66	Formats output-- Example: C{3} = 0.500 v x 100 = 500 A{3} = 60 scans x 10,000 = 600000 600500 goes to D{5}.
67	If printer is out of paper when line 68 executes, goes to "err".
68	If printer is not out of paper, prints D{1}, date; and D{2}, station ID.
69	Error no. 15 (printer out of paper) sends execution to line 75.
70	Format number 1, "print" "ch", skip 2 spaces; (f 2.0) = 2 spaces for channel number 1-16, with zero places to right of decimal, skip 3 spaces, (f 7.0) = 7 spaces for result of line 57: ch _ _ 1 6,_ _ _,_ 6 0 1 3 1 9.
71	Sets up loop to print hourly data for each of 16 channels.
72	Prints each channel at device 16 (internal printer) according to format 1 given in line 57.
73	Continues loop until all channels are printed.
74	If printer not out of paper, prints " "; skips 2 lines.
75	Records hourly data on tape.
76	Sets up loop to reset array variable to zero.
77	Sets array variables for each channel to zero.
78	Starts all over again at line 13.
79	Increments counter of one-minute scans for channel 8.
80	Calculates wind direction.
81	B{7} = wind speed; sums true wind speed (cos θ) in B{8}.
82	Same as line 81, but for sin θ.
83	Returns to line 45.

Line No.	Direction
f_0	Requests calibration channel and isolates selected channel from hourly data.
f_1	Ends calibration channel isolation; lists channels that were isolated.
f_2	Operator event: restarts data acquisition when program execution is halted by operator to perform maintenance, etc.; use of this key retains the hourly data accumulated to the point of operator interruption (if program execution is restarted with the "run" key or the autostart feature, the data for that hour is lost, as all variables reset to zero).
f_0	"Z" refers to line 32; requests calibration channels; "1 + D{20} + D{20}" is bookkeeping variable stored in D{20} to indicate calibration was taking place during execution at line 3.
f_1	Lists calibration channels that were isolated and returns those channels to hourly data accumulation; "100 + D{20} + D{20}" is bookkeeping device.
f_2	Restarts data acquisition after program halt due to operator interruption and saves the hourly data accumulated up to the time of the operator interruption; "10,000 + D{20} + D{20}" is bookkeeping device.

```
0: ldk 1
1: dim A[18],
 B[18],C[18],
 D[20]
2: prt "ARE WIND
  SPEED SLOPE
 AND INTERCEPT
 ENTERED LINE
 81&82"
3: D[20]+.01→D[2
 0]
4: 7→r5;wtb 2,32
5: gto 13
6: "trig":B[8]→B
 [8];B[18]→B[18]
 ;√(B[8]↑2+B[18]
 ↑2)→C[7]
7: atn(B[18]/
 B[8])→r12
8: if B[18]<0
 and B[8]<0;0→r1
 3
9: if B[18]<0
 and B[8]>0;2→r1
 3
10: if B[18]>0
 and B[8]>0;3→r1
 3
11: if B[18]>0
 and B[8]<0;4→r1
 3
12: fxd 3;90r13+
 r12→C[8];C[8]/
 1000→C[8];ret
13: wrt 9,"R";
 8000000000→K;
 62142→D[1];fxd
 2
14: red 9,A,B,C,
 D,E
15: dsp A,B,C,D,
 E;wait 50
16: if D=F;gto
 13
17: if r6=0;D→F;
 C→G;1→r6;gto 13
18: D→F;0→J
19: fxd 3;J+1→J;
 if J=17;wtb 2,
 32;gto 50
20: wtb 2,32;
 wait 10;wtb 2,
 J;wait 50;0→I
21: T+1→T;if
 T=11;0→T;gto 33
22: rdb(2)→X;
 wait 30;int(X)→
 X
23: rdb(2)→Y;
 wait 30;int(Y)→
 Y
24: on err "66"
25: if X/Y<.9
 or X/Y>1.1;gto
 22
26: "66":if erl=
 26;gto 27
27: I+1→I;if
 I=5;0→I;gto 29
28: rot(X,4I)→rI
 ;shf(rI,12)→rI;
 gto 27
29: r1+10r2+100r
 3+1000r4→X;X/
 1000→X
30: if X<3.999;
 X*-1→X
31: if X>=3.999;
 X-4→X
32: X+U→U;gto 21
33: U/10→X;0→U
34: if Z=9;enp
 "CAL CH.#,L-Q",
 L,M,N,O,P,Q;
 0→Z;gto 13
35: if J=L;beep;
 wait 5000;beep;
 gto 47
36: if J=M;beep;
 wait 10;beep;
 gto 47
37: if J=N;beep;
 wait 10;beep;
 gto 47
38: if J=O;beep;
 wait 10;beep;
 gto 47
39: if J=P;beep;
 wait 10;beep;
 gto 47
40: if J=Q;beep;
 wait 10;beep;
 gto 47
41: if X>4;4→X
42: if X<-1;gto
 47
43: if J≠8;gto
 46
44: if J=8;gsb
 "trig1"
45: gto 47
46: X+B[J]→B[J];
 A[J]+1→A[J];
 fxd 3
47: if J>9;dsp
 "Ch =",J,"
 Voltage =",X;
 wait 300
48: if J<10;dsp
 "Ch = ",J,"
 Voltage =",X;
 wait 300
49: gto 19
50: wait 1;fxd
 2;if C=G;gto 13
51: K+1000000A+
 10000B+100C+
 D→D[2]
52: C→G;wtb 2,
 32;24B+C-22→H;
 fxd 0
53: if H<370;0→W
54: if H>370;H-
 370→H;1→W
55: trk W
56: on err "perr
 "
57: if ern≠15;
 fmt 2,"Trk",
 f2.0,", File#",
 f4.0;wrt 16.2,
 W,H
58: "perr":if
 ern=15;jmp 1
59: 0→I
60: I+1→I;if
 I=17;gto 67
61: if I=8;gto
 66
62: if I≠r5;gto
 65
63: fxd 3;gsb
 "trig"
64: gto 66
65: if A[I]>0;
 B[I]/A[I]→C[I]
66: fxd 0;1000C[
 I]+10000A[I]→D[
 I+2];gto 60
67: on err "err"
68: if ern≠15;
 prt D[1];prt
 D[2]
69: "err":if
 ern=15;gto 75
70: 2→I;fxd 0;
 fmt 1,"Ch",2x,
 f2.0,3x,f7.0
71: I+1→I;if
 I=19;gto 74
72: if ern≠15;
 wrt 16.1,I-2,
 D[I]
73: gto 71
74: if ern≠15;
 prt "";prt ""
75: rcf H,D[*];
 0→I
76: I+1→I;if
 I=19;gto 78
77: 0→A[I]→B[I]→
 C[I];gto 76
78: 0→D[20];gto
 13
79: "trig1":A[8]
 +1→A[8]
80: 540X→r10
81: (-(B[7]1.000
 1+.0101))cos(r1
 0)+B[8]→B[8]
82: (-(B[7]1.000
 1+.0101))sin(r1
 0)+B[18]→B[18]
83: ret
*20771

f0: *9→Z;1+D[20]
 →D[20];ldf0,0,4

f1: *prt"CAL CHN
 LS",L,M,N,O,P,Q
 ;0→L→M→N→O→P→Q;
 prt"CAL END";10
 0+D[20]→D[20];1
 df0,0,4

f2: *prt"OPERATO
 REVENT";10000+D
 [20]→D[20];ldf0
 ,0,4
```

Figure 13. Data acquisition system software listing.

TABLE 7. PROCEDURE FOR CALCULATING AVERAGE WIND DIRECTION

Definition of symbols:

θ = direction from which the wind blows, measured clockwise from north (usually gridnorth).

V = wind velocity.

$\bar{V}$ = average wind velocity for a given hour.

μ = westerly wind speed component, with west defined as positive.

$\bar{\mu}$ = westerly wind speed component summed over an hour.

ν = southerly wind speed component, with south defined as positive.

$\bar{\nu}$ = southerly wind speed component summed over an hour.

Calculations:

$$\mu = -V \sin \theta$$

$$\nu = -V \cos \theta$$

$$\bar{\mu} = \frac{1}{60} \sum_{1}^{60} \mu_i$$

$$\bar{\nu} = \frac{1}{60} \sum_{1}^{60} \nu_i$$

$$\bar{V}/60 = (\bar{\mu}^2 + \bar{\nu}^2)^{0.5}, \quad \theta = \arctan\,(\bar{\mu}/\bar{\nu})$$

Examine the sign of $\bar{\nu}$ and $\bar{\mu}$:

if both are -, then $0 < \theta < 90$;

if $\bar{\mu}$ is - and $\bar{\nu}$ is +, then $90 < \theta < 180$;

if both are +, then $180 < \theta < 270$;

if $\bar{\mu}$ is + and $\bar{\nu}$ is -, then $270 < \theta < 360$.

(See Figure 14.)

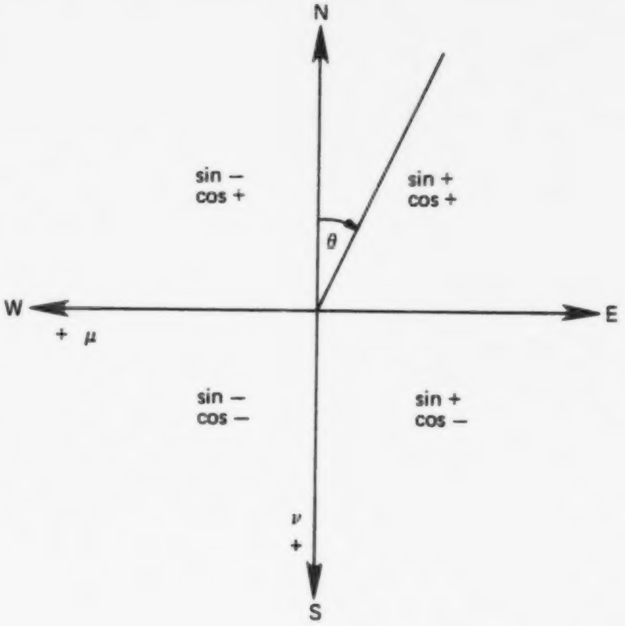
N
sin −
cos +
sin +
cos +
θ
W
+ μ
E
sin −
cos −
sin +
cos −
ν
+
S

Figure 14. Diagram of components of wind-speed calculations.

APPENDIX A

DATA FROM OPERATIONAL PERFORMANCE TESTING OF THE OHIO RIVER VALLEY AIR-MONITORING STATIONS

Appendix A contains the calibration and audit data documenting the performance of the continuous analyzers (NO-NO_x-NO_2, sulfur, O_3, and nephelometer) during the period of performance testing. Following the calibration audit data for each station are plots of the data decoded from tapes made during the performance tests. Missing records are explained below each plot.

TABLE A-1. NO, NO_x, AND NO_2 CALIBRATION AND AUDIT DATA FOR STATION NO. 062103 (FRANKLIN CO., IN)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791206	(moved NO_x analyzer SN 9707 from station no. 062042 to no. 062103)					
791207*	NO	0.0	0.1	--	994	454
	NO_x	0.0	0.2	--		504
	NO_2	0.0	0.6	--		
	NO	95.0	95.0	0		
	NO_x	95.0	95.0	0		
	NO_2	0.0	1.1	--		
		(UV lamp on)				
	NO	19.2	19.2	0		
	NO_x	95.0	98.4			
	NO_2	75.0	79.0			
	NO	29.1	29.1	0		
	NO_x	95.0	99.3	4.5		
	NO_2	66.0	69.7	3.9		
	NO	57.2	57.2	0		
	NO_x	95.0	99.3	4.5		
	NO_2	38.0	42.8	12.6		
	NO	74.1	74.1	0		
	NO_x	95.0	99.2	4.4		
	NO_2	21.0	26.2	24.7		
791210†	NO	0	4.0	--	994	454
	NO_x	0	2.0	--		504
	NO_2	0	-1.0	--		

---

*Calibration.
†Audit.

(continued)

TABLE A-1 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791210† (cont'd)	NO	95.0	95.0	0		
	NO_x	95.0	96.0	1.0		
	NO_2	0	2.0	--		
		(UV lamp on)				
	NO	18.8	22.0	17.0		
	NO_x	95.0	95.0	0		
	NO_2	76.2	73.0	4.2		
791211†	NO	0	6.0	--	994	454
	NO_x	0	5.0	--		504
	NO_2	0	0	--		
	NO	95.0	98.0	3.0		
	NO_x	95.0	99.0	4.0		
	NO_2	0	4.0	--		
	NO	12.2	17.0	39.0	994	454
	NO_x	95.0	101.1	6.4		504
	NO_2	82.8	82.0	1.0		
791213*	NO	0	4.0	--	994	454
	NO_x	0	3.0	--		504
	NO_2	0	1.0	--		
	NO	95.0	98.0	3.2		
	NO_x	95.0	98.0	3.2		
	NO_2	0	3.0	--		
		(UV lamp on)				

---

*Calibration.
†Audit.

(continued)

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TABLE A-1 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791213* (cont'd)	NO	30.3	34.0	12.2		
	NO_x	95.0	97.0	1.1		
	NO_2	64.7	63.0	-2.6		
791214†	NO	0	4.0	--	994	454
	NO_x	0	1.0	--		504
	NO_2	0	-1.0	--		
	NO	95.0	98.0	3.2		
	NO_x	95.0	98.0	3.2		
	NO_2	0	2.0	--		
		(UV lamp on)				
	NO	20.2	24.0	18.8		
	NO_x	95.0	93.0	-2.1		
	NO_2	74.8	67.0	-10.4		
791217*	NO	0	0.2	--	997	492
	NO_x	0	0.3	--		529
	NO_2	0	0.6	--		
	NO	95.0	94.8	-0.2		
	NO_x	95.0	95.8	0.8		
	NO_2	0	2.1	--		
		(UV lamp on)				
	NO	18.1	18.2	0.6		
	NO_x	95.0	92.3	-2.8		
	NO_2	76.8	77.6	1.0		
		(performed electrical alignment of NO_x analyzer)				

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*Calibration.
†Audit.

(continued)

TABLE A-1 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791218*	NO	0	1.8	--	998	433
	NO_x	0	0.7	--		493
	NO_2	0	-1.1	--		
	NO	95.0	95.4	0.4		
	NO_x	95.0	96.3	1.4		
	NO_2	0	2.5	--		
		(UV lamp on)				
	NO	13.5	15.1	11.9		
	NO_x	95.0	96.0	1.1		
	NO_2	81.5	80.1	-1.7		
	NO	45.3	46.5	2.6		
	NO_x	95.0	96.8	1.9		
	NO_2	44.7	40.8	-8.7		
	NO	76.2	76.9	0.9		
	NO_x	95.0	96.8	1.9		
	NO_2	18.8	20.3	8.0		
791219†	NO	0	5.6	--	998	433
	NO_x	0	3.8	--		493
	NO_2	0	0	--		
	NO	95.0	96.0	1.1		
	NO_x	95.0	97.5	2.6		
	NO_2	0	8.1	--		
		(UV lamp on)				
	NO	43.9	47.4	8.0		
	NO_x	95.0	98.1	3.3		
	NO_2	51.1	51.7	1.2		

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*Calibration.
†Audit.

(continued)

TABLE A-1 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791220†	NO	0	3.8	--	998	433
	NO_x	0	2.4	--		493
	NO_2	0	0	--		
	NO	95.0	91.8	3.4		
	NO_x	95.0	92.7	2.4		
	NO_2	0	2.3	--		
		(UV lamp on)				
	NO	23.8	25.8	8.4	998	433
	NO_x	95.0	90.8	4.4		493
	NO_2	71.2	64.4	9.6		
791221†	NO	0	3.3	--	998	433
	NO_x	0	2.5	--		493
	NO_2	0	0.1	--		
	NO	95.0	96.8	1.8		
	NO_x	95.0	98.8	3.5		
	NO_2	0	3.6	0		
		(UV lamp on)				
	NO	31.1	33.9	9.0		
	NO_x	95.0	97.6	2.7		
	NO_2	63.9	67.2	5.2		
	NO	56.5	59.7	5.7		
	NO_x	95.0	96.8	1.9		
	NO_2	38.5	38.8	0.8		
	NO	85.5	89.1	4.2		
	NO_x	95.0	97.5	2.6		
	NO_2	9.5	9.1	4.2		

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†Audit.

(continued)

TABLE A-1 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791227†	NO	0	6.0	--	998	433
	NO_x	0	4.4	--		493
	NO_2	0	0	--		
	NO	95.0	90.4	-4.8		
	NO_x	95.0	91.2	-4.0		
	NO_2	0	2.4	--		
		(UV lamp on)				
	NO	12.8	17.4	35.9		
	NO_x	95.0	89.8	-5.5		
	NO_2	82.2	72.3	-12.0		
	NO	27.0	30.2	11.9		
	NO_x	95.0	88.0	-7.4		
	NO_2	68.0	57.0	-16.2		
800102*	NO	0	0.3	--	993	432
	NO_x	0	0.2	--		492
	NO_2	0	0	--		
	NO	95.0	95.0	0		
	NO_x	95.0	95.0	0		
	NO_2	0	0.8	--		
		(UV lamp on)				
	NO	19.7	19.7	0		
	NO_x	95.0	96.7	1.8		
	NO_2	76.3	76.5	0.3		
	NO	38.3	38.3	0		
	NO_x	95.0	97.3	2.4		
	NO_2	56.7	59.0	4.1		
	NO	62.5	62.5	1.0		
	NO_x	95.0	97.3	2.4		
	NO_2	32.5	35.6	9.5		

*Calibration.
†Audit.

TABLE A-2. O_3 CALIBRATION AND AUDIT DATA FOR STATION NO. 062103 (FRANKLIN CO., IN)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791207*	0	7.0	--	009	487
	75.0	75.1	0.1		
791210*	0	2.0	--	010	332
	76.0	75.1	-1.2		
791211†	0	0.3	--	010	332
	81.0	78.1	-2.3		
791213†	0	-0.2	--	010	332
	65.0	64.0	-1.5		
791214†	0	4.0	--	010	332
	74.8	68.0	-7.6		
791217†	0	0.3	--	010	332
	76.8	73.0	-2.9		
791218*	0	0.4	--	009	342
	81.5	81.5	0		
	41.0	44.0	7.3		
	20.0	19.5	-2.5		
791219†	0	0.6	--	009	342
	51.1	49.8	-0.6		
791220†	0	0.3	--	009	342
	71.2	71.5	1.4		
791221†	0	1.0	--	009	342
	64.0	67.0	4.7		
	37.0	37.1	0.3		
	9.1	9.4	3.3		
791227†	0	0.007	--	009	342
	82.0	80.5	1.8		
	68.0	64.2	-5.6		
800102†	0	0.003	--	009	342
	76.5	73.8	-3.5		

*Calibration.
†Audit.

TABLE A-3. TOTAL SULFUR CALIBRATION AND AUDIT DATA FOR STATION NO. 062103 (FRANKLIN CO., IN)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791205*	84.0	83.8	-0.2	2335	2812
	35.0	38.0	8.6		
	22.0	21.5	2.3		
	0	-2.2	--		
791207†	0	3.6	--	2335	2812
	84.0	84.4	0.5		
791210*	0	-0.7	--	2347	2821
	84.0	84.3	0.4		
	35.0	38.6	10.3		
	22.0	25.4	0.15		
791211*	0	-0.3	--	2347	2822
	84.0	83.2	-1.0		
791213†	0	-1.1	--	2347	2822
	84.0	86.0	2.4		
791214†	0	-0.7	--	2347	2822
	84.0	83.4	-0.7		
791217†	0	-1.3	--	2347	2821
	84.0	83.8	-0.2		
	52.0	55.7	7.1		
	35.0	37.6	7.4		
	22.0	23.5	6.8		
791218†	0	-0.5	--	2347	2821
	84.0	86.4	2.8		
791219†	0	-1.4	--	2347	2821
	84.0	86.0	2.4		
791220†	0	-1.4	--	2347	2821
	84.0	84.4	0.5		

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*Calibration.
†Audit.

(continued)

TABLE A-3 (continued)

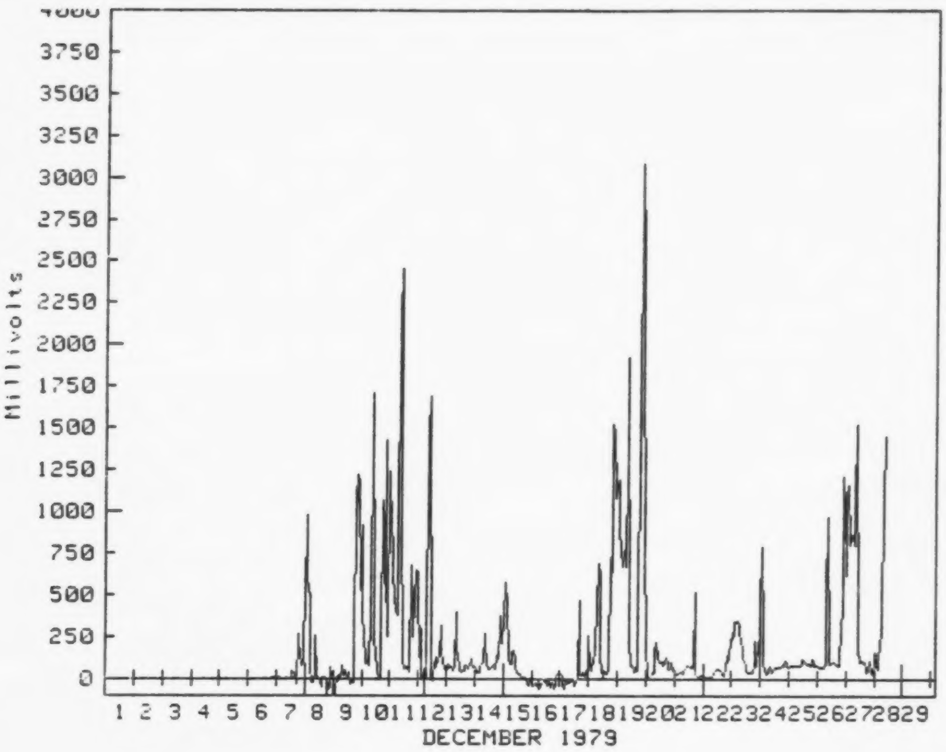
Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791221†	0	-1.1	--	2347	2821
	84	84.8	1.0		
	52	56.3	8.3		
	35	37.2	6.3		
	22	20.6	-6.4		
791227†	0	-2.7	--	2347	2821
	84	80.4	4.3		
800102*	0	-2.1	--	2347	2820
	84	84.2	0.2		

*Calibration.
†Audit.

TABLE A-4. NEPHELOMETER CALIBRATION AND AUDIT DATA FOR STATION NO. 062103 (FRANKLIN CO., IN)

Date	Electric Zero (volts)	Air Zero (volts)	Electric Cal. (volts)	Freon (volts)
791205†	-0.001	0.006	4.036	1.190
791207†	0.004	-0.006	4.065	1.184
791210†	0.036	0.022	3.953	1.214
791211†	0.013	0.080	4.036	--
791213†	0.059	0.024	4.110	--
791214†	0.054	-0.017	4.108	--
791217†	-0.026	-0.078	3.668	1.031
791218*	0.001	-0.052	4.013	1.210
791219†	0.041	0.028	4.108	1.218
791220†	-0.014	-0.017	4.108	--
791221†	0.029	0.012	4.248	1.273
791227†	0.018	0.014	4.242	--
800102†	0.040	0.018	4.162	--

*Calibration.
†Audit.



MISSING RECORDS:

791206 installed NO_x analyzer 9707

Figure A-1. NO air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).

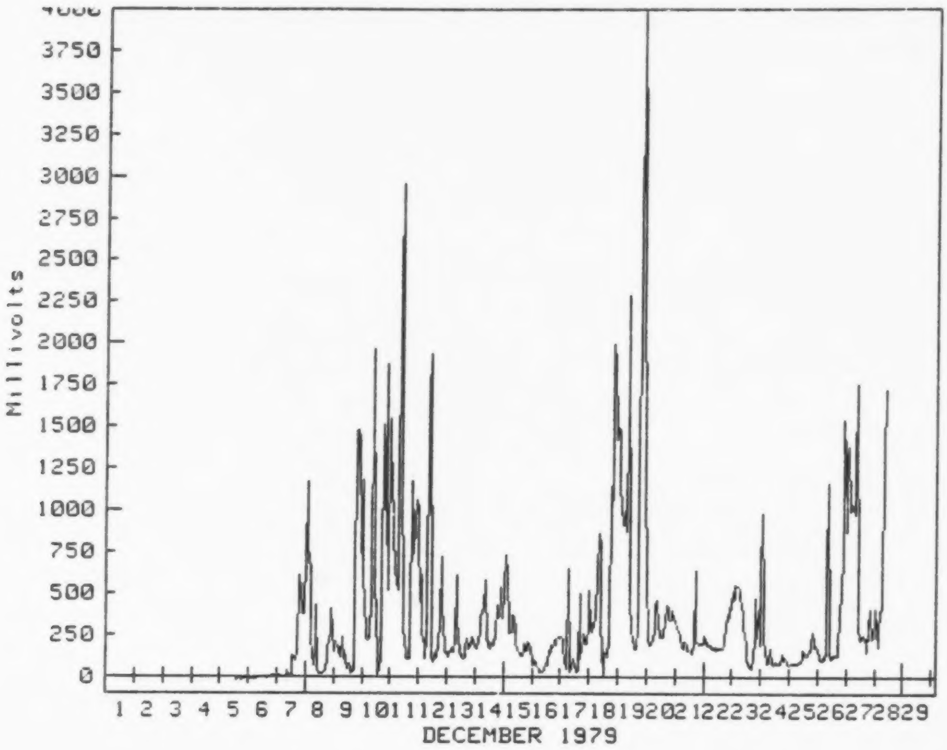


Figure A-2. Total NO_x air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).

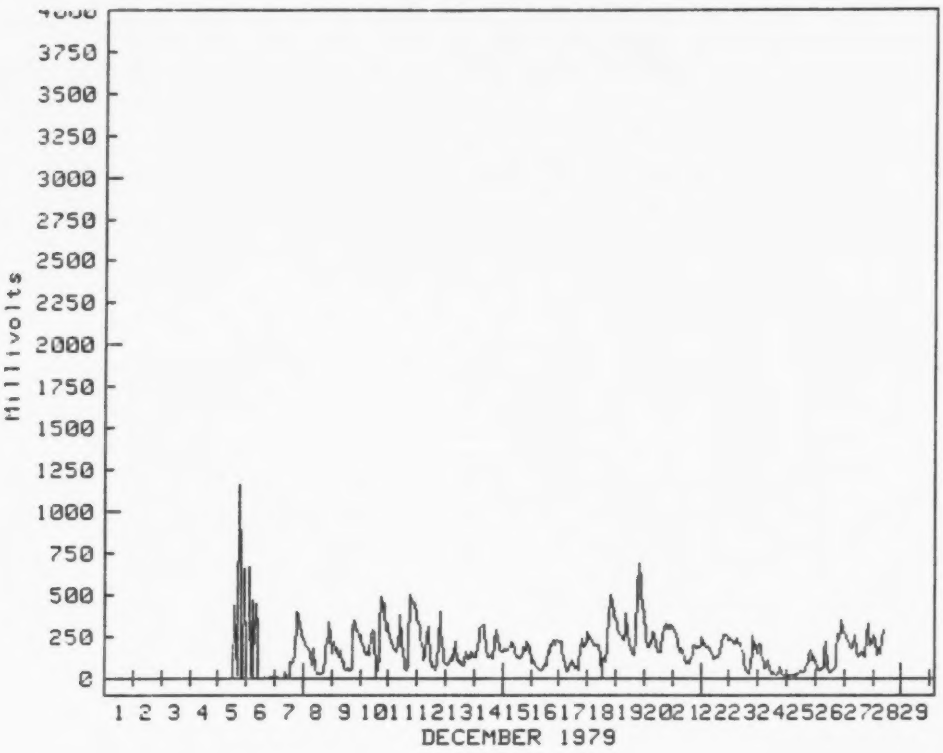
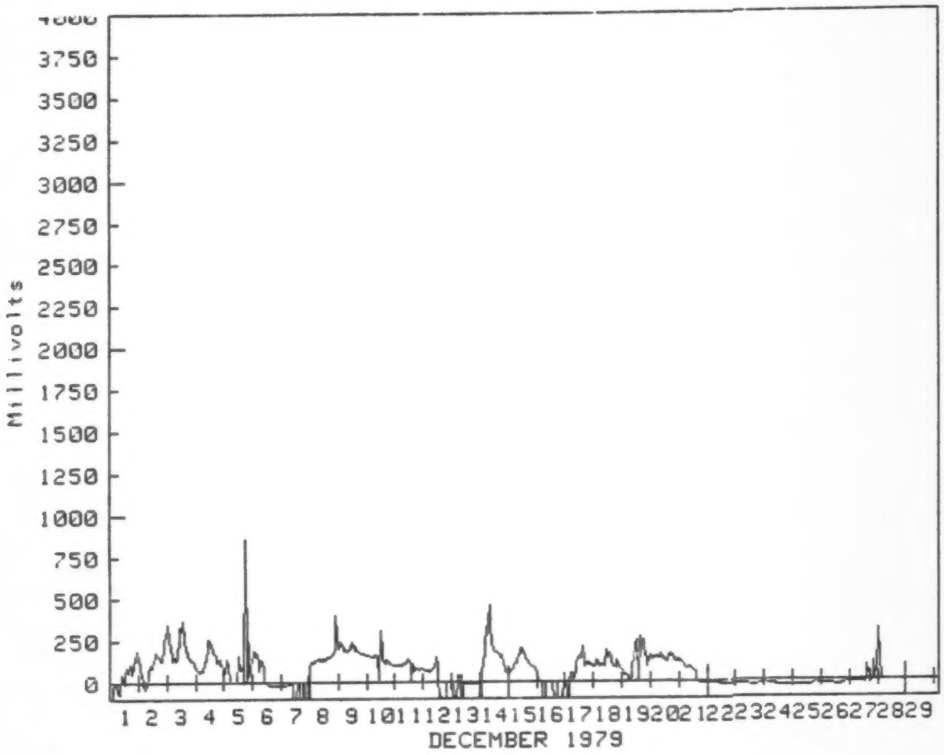


Figure A-3. NO_2 air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).



MISSING RECORDS:

791207 excessively negative reading due to data acquisition software problem

791212-791214 (same)

791216 (same)

Figure A-4. Total sulfur air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).

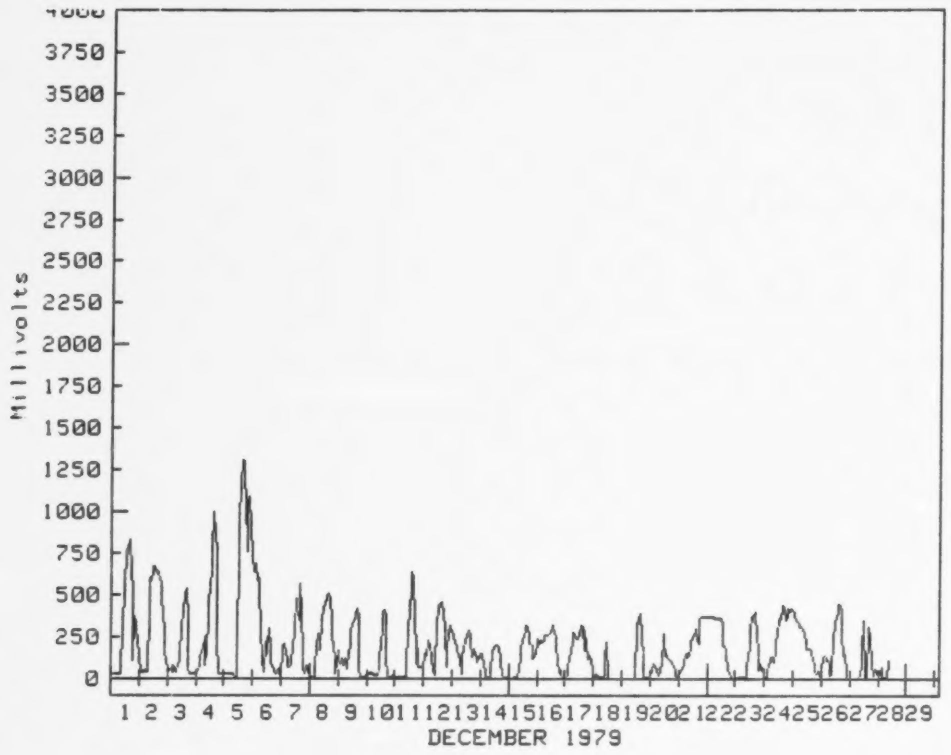
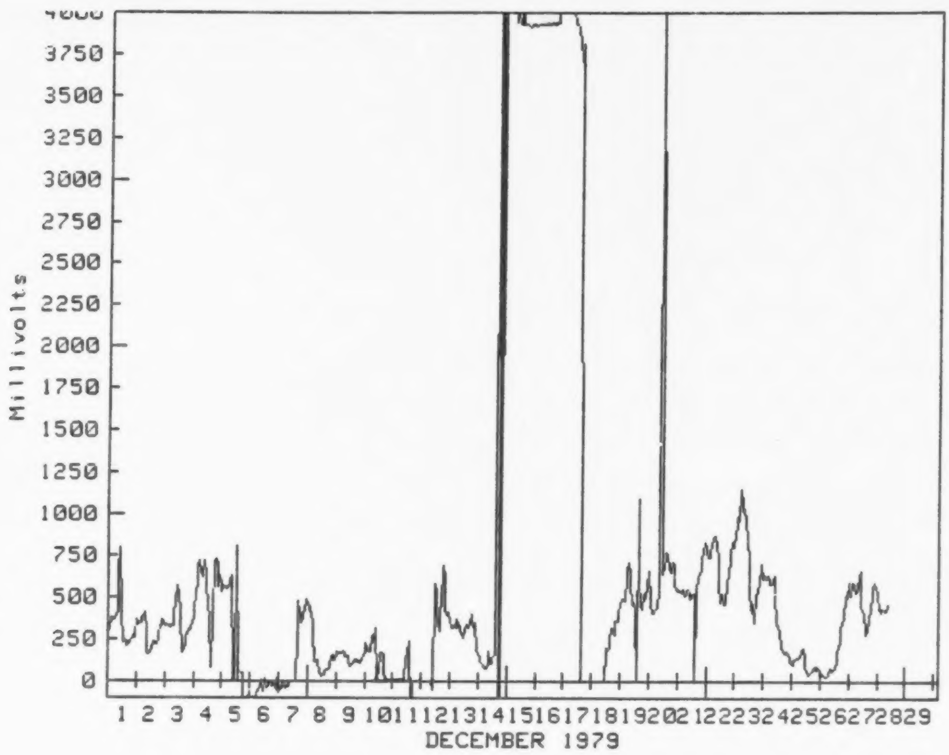


Figure A-5. O_3 air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).



MISSING RECORDS:

791210-791211	connector wire pulled loose from output terminal
791214-791217	calibration switch left on
791217-791218	isolated by operator

Figure A-6. Nephelometer air-monitoring data from 15-day operational test of station no. 062103 (Franklin Co., IN).

TABLE A-5. NO, NO_x, AND NO_2 CALIBRATION AND AUDIT DATA FOR STATION NO. 062042 (ASHLAND CO., OH)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791127*	NO	0	1.5	--	980	305
	NO_x	0	-0.3			322
	NO_2	0	0.1			
	NO	95.0	95.0	0		
	NO_x	95.0	95.2	0.2		
	NO_2	0	0.1	--		
		(UV lamp on)				
	NO	20.8	22.0	5.8		
	NO_x	95.0	96.0	1.0		
	NO_2	74.2	74.0	-0.3		
791128†	NO	0	0.4	--	980	305
	NO_x	0	0.7	--		322
	NO_2	0	-0.2	--		
	NO	90.0	90.4	0.4		
	NO_x	90.0	90.1	0.1		
	NO_2	0	-0.4	--		
		(UV lamp on)				
	NO	9.5	9.9	4.2		
	NO_x	90.0	86.2	4.2		
	NO_2	80.5	75.0	6.8		
791130†	NO	0	1.0	--	980	305
	NO_x	0	7.0	--		322
	NO_2	0	-2.8	--		

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*Calibration.

†Audit.

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TABLE A-5 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791130† (cont'd)	NO	90.0	94.0	4.4		
	NO_x	90.0	93.0	3.3		
	NO_2	0	-1.8	--		
		(UV lamp on)				
	NO	15.5	17.0	9.7		
	NO_x	90.0	92.5	2.8		
	NO_2	74.5	75.0	0.7		
791204†	NO	0	9.0	--	980	305
	NO_x	0	7.2	--		322
	NO_2	0	-1.6	--		
	NO	90.0	87.0	3.3	980	305
	NO_x	90.0	86.5	3.9		322
	NO_2	0	-1.1	--		
		(UV lamp on)				
	NO	18.5	25.0	35.0		
	NO_x	90.0	85.0	-5.6		
	NO_2	71.5	57.0	-14.5		
791205†	NO	0	-0.7	--	980	305
	NO_x	0	-2.2	--		322
	NO_2	0	-1.2	--		
	NO	90.0	87.5	-2.8		
	NO_x	90.0	84.5	-6.1		
	NO_2	0	-2.1			
		(UV lamp on)				

---

†Audit.

(continued)

TABLE A-5 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791205† (cont'd)	NO	25.8	24.6	-4.7		
	NO_x	90.0	85.6	-4.9		
	NO_2	64.8	57.3	11.6		
791206†	NO	0	0.3	--	980	305
	NO_x	0	4.1	--		322
	NO_2	0	0.9	--		
	NO	90.0	88.0	-2.2		
	NO_x	90.0	86.8	-3.6		
	NO_2	0	-1.1	--		
		(UV lamp on)				
	NO	23.3	25.1	7.7		
	NO_x	90.0	85.5	5.0		
	NO_2	65.0	58.1	10.6		
	(moved NO_x analyzer SN 9707 from station no. 062042 to station no. 062103)					
791212†	(installed newly repaired NO_x analyzer SN9894 from station no. 062103)					
791212*	NO	0	0	--	986	289
	NO_x	0	0.3	--		329
	NO_2	0	0.3	--		
	NO	95.0	95.0	0		
	NO_x	95.0	95.0	0		
	NO_2	0	0	--		

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*Calibration.
†Audit.

(continued)

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TABLE A-5 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791212* (cont'd)		(UV lamp on)				
	NO	24.0	24.0	0		
	NO_x	95.0	93.0	-2.1		
	NO_2	71.0	74.0	4.2		
791214†	NO	0	-1.4	--	986	289
	NO_x	0	6.0	--		329
	NO_2	0	0	--		
	NO	95.0	90.0	-5.3		
	NO_x	95.0	93.0	-2.1		
	NO_2	0	0.4	0		
		(UV lamp on)				
	NO	27.3	24.9	-2.4		
	NO_x	95.0	95.6	0.6		
	NO_2	67.7	65.0	4.0		
791217*	NO	0	-0.1	--	970	305
	NO_x	0	0.3	--		360
	NO_2	0	0	--		
	NO	95.0	95.0	0		
	NO_x	95.0	95.0	0		
	NO_2	0	0	--		
		(UV lamp on)				
	NO	22.0	22.4	1.8		
	NO_x	95.0	96.0	1.1		
	NO_2	72.6	73.4	-1.1		

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*Calibration.
†Audit.

(continued)

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TABLE A-5 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791218*	NO	0	3.4	--	968	305
	NO_x	0	1.1	--		360
	NO_2	0	1.6	--		
	NO	95.0	95.3	0.3	968	305
	NO_x	95.0	95.5	0.5		360
	NO_2	0	0.2	0		
		(UV lamp on)				
	NO	13.0	16.0	23.0		
	NO_x	95.0	92.5	2.6		
	NO_2	82.0	73.8	10.0		
791219†	NO	0	1.8	--	968	305
	NO_x	0	3.2	--		360
	NO_2	0	1.8	--		
	NO	95.0	94.4	0.6		
	NO_x	95.0	98.4	3.6		
	NO_2	0	4.0	--		
		(UV lamp on)				
	NO	15.7	17.2	9.6		
	NO_x	95.0	96.0	1.1		
	NO_2	79.3	74.8	5.7		

*Calibration.
†Audit.

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TABLE A-6. O_3 CALIBRATION AND AUDIT DATA FOR STATION NO. 062042 (ASHLAND CO., OH)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791127*	0 73.0	0.9 73.2	-- 0.3	010	337
791128†	0 84.0	1.3 85.7	-- 2.0	010	337
791130†	0 76.0	2.0 79.3	-- 4.3	010	337
791204†	71.5 0	64.0 1.5	-11.7 --	010	337
791205†	0 64.0	1.1 62.0	-- -3.1	010	337
791206†	0 66.6	1.1 69.0	-- 3.6	010	337
791211†	62.0 0	66.0 1.0	3.2 --	010	337
791212†	0 71.0	0.3 70.0	-- -1.4	010	337
791214†	0 64.0	1.4 67.0	-- 4.7	010	337
791217†	0 73.4	1.1 76.1	-- 3.7	010	337
791218*	0 82.0	0.3 79.3	-- 3.3	001	332
791219†	0 79.0	1.5 78.6	-- 0.5	001	332

*Calibration.
†Audit.

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TABLE A-7. TOTAL SULFUR CALIBRATION AND AUDIT DATA FOR STATION NO. 062042 (ASHLAND CO., OH)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791127*	84.0	84.0	0	235	688
	22.0	22.0	0		
	55.0	55.7	1.3		
	0	0.3	--		
791128*	0	0.4	--	572	503
	84.0	85.7	2.0		
791130†	0	4.6	--	572	503
	84.0	86.0	2.4		
791204†	0	8.1	--	572	503
	84.0	86.0	2.4		
791205†	0	6.8	--	572	503
	84.0	84.1	0.1		
791206†	0	4.8	--	572	503
	84.0	85.5	1.8		
791210†	0	0.7	--	572	503
	84.0	85.7	2.0		
791211*	0	3.6	--	476	503
	84.0	85.0	1.2		
	22.0	21.3	3.2		
791212†	0	-3.0	--	476	503
	84.0	89.0	6.0		
791214†	0	-1.7	--	476	503
	84.0	86.0	2.4		

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*Calibration.
†Audit.

(continued)

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TABLE A-7 (continued)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
791217†	0	-1.4	--	476	503
	84.0	84.2	0.2		
791218†	0	-2.1	--	476	503
	84.0	82.0	2.4		
791219†	0	-2.3	--	476	503
	84.0	80.1	4.6		

†Audit.

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TABLE A-8. NEPHELOMETER CALIBRATION AND AUDIT DATA FOR STATION NO. 062042 (ASHLAND CO., OH)

Date	Electric Zero (volts)	Air Zero (volts)	Electric Cal. (volts)	Freon (volts)
791102†	-0.005	0.138	not working	not performed
791119†		(bulb burned out in nephelometer)		
791204†	0.005	0.003	not working	1.224
791205†	0.008	-0.011	not working	1.234
791206†	-0.006	-0.010	not working	1.240
791211†		(off to repair electric cal. motor)		
791218*	-0.001	0-0.003	3.863	1.217
791219*	0.003	0-0.001	3.925	1.205
791220†	0	0.036	3.893	

*Calibration.
†Audit.

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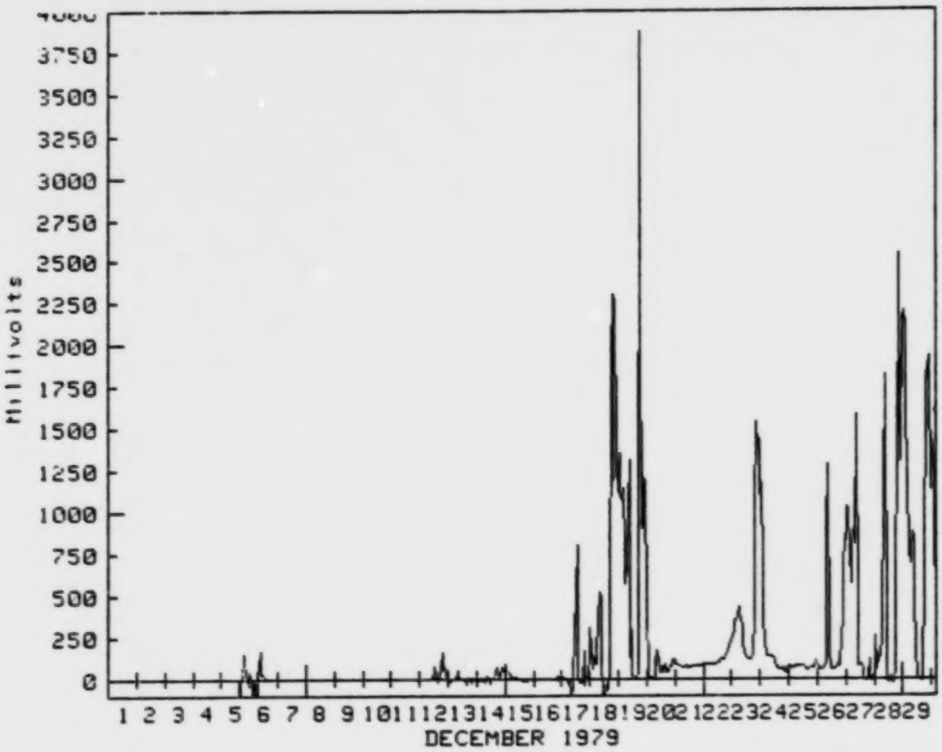

MISSING RECORDS:

791206 NO_x analyzer 9707 moved to station no. 062103

791212 NO_x analyzer 9894 installed

Figure A-7. NO air-monitoring data from 7-day operational test of station no. 062042 (Ashland Co., OH).

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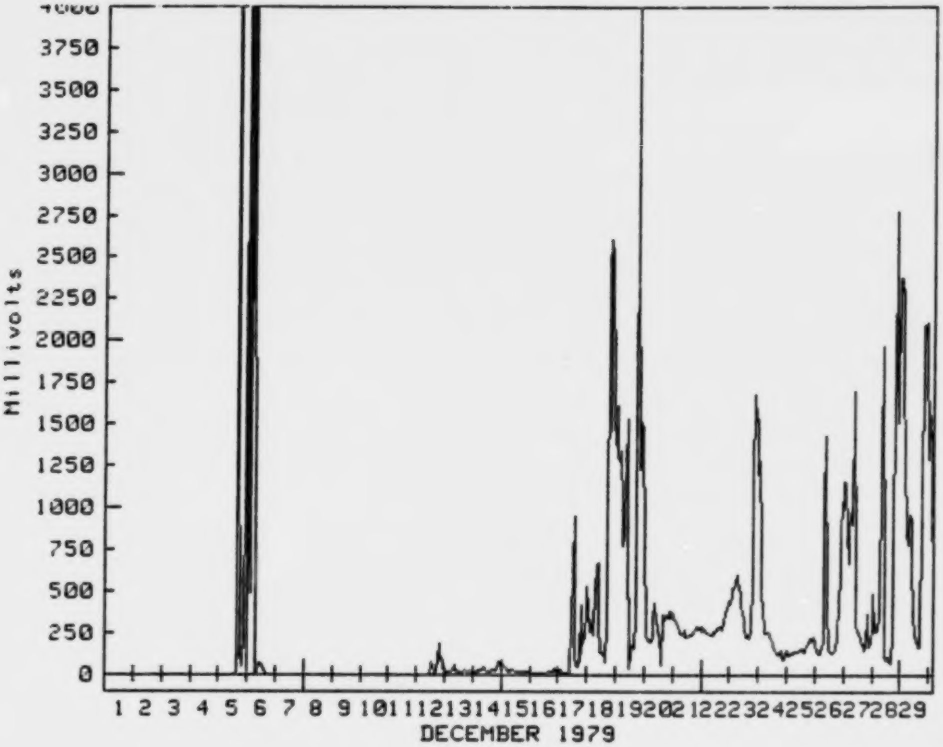

Figure A-8. Total NO_x air-monitoring data from 7-day operational test of station no. 062042 (Ashland Co., OH).

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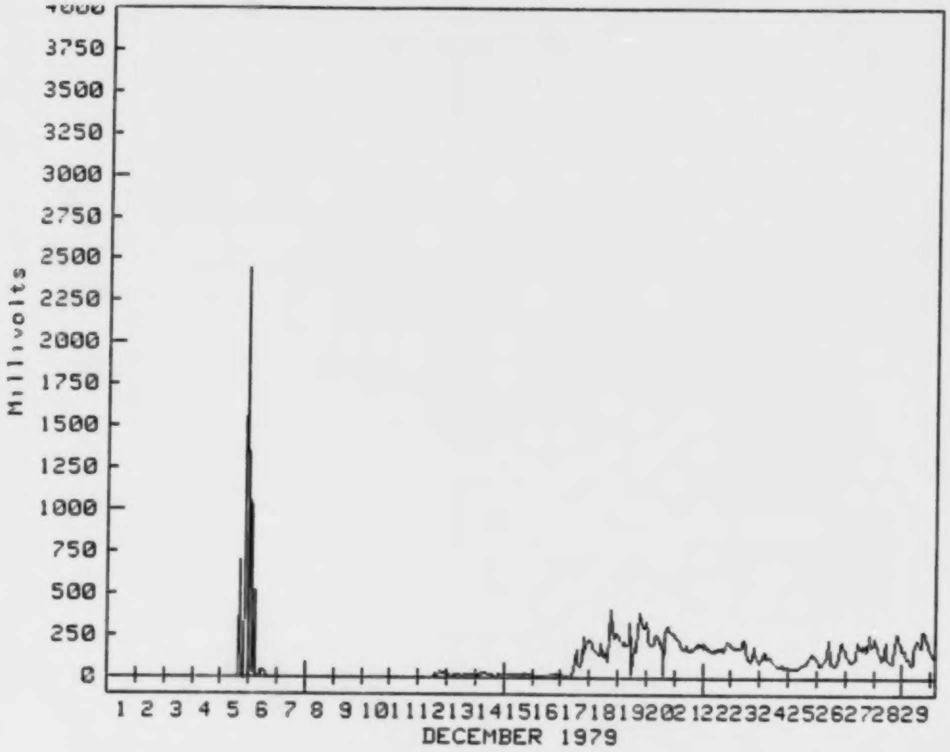

Figure A-9. NO_2 air-monitoring data from 7-day operational test of station no. 062042 (Ashland Co., OH).

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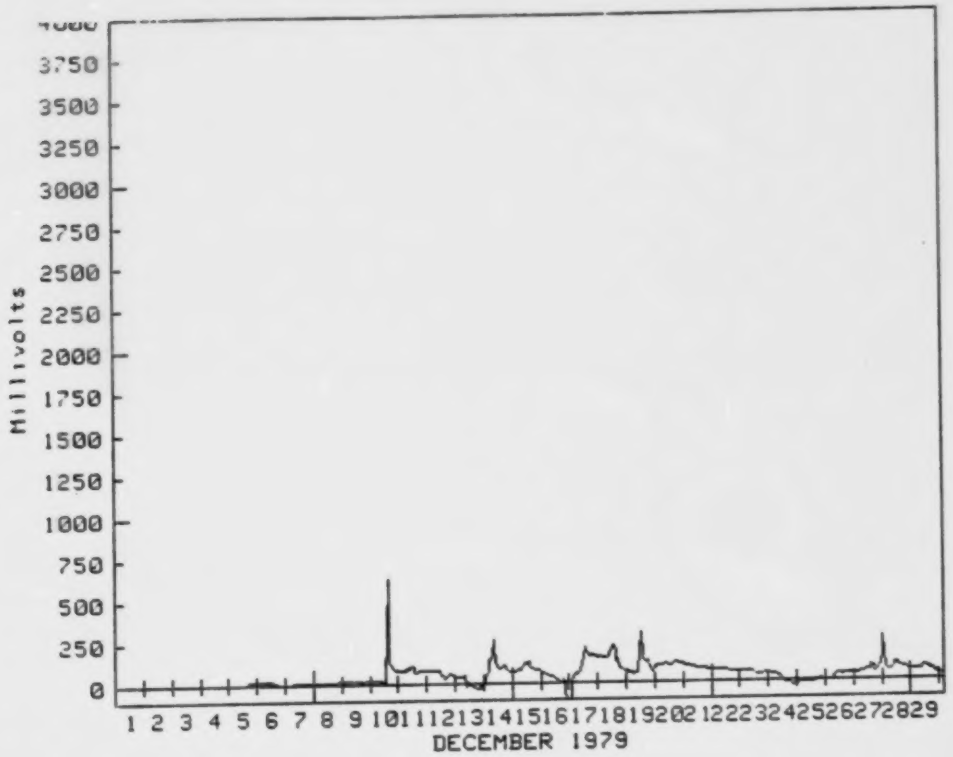

Figure A-10. Total sulfur air-monitoring data from 7-day operational test of station no. 062042 (Ashland Co., OH).

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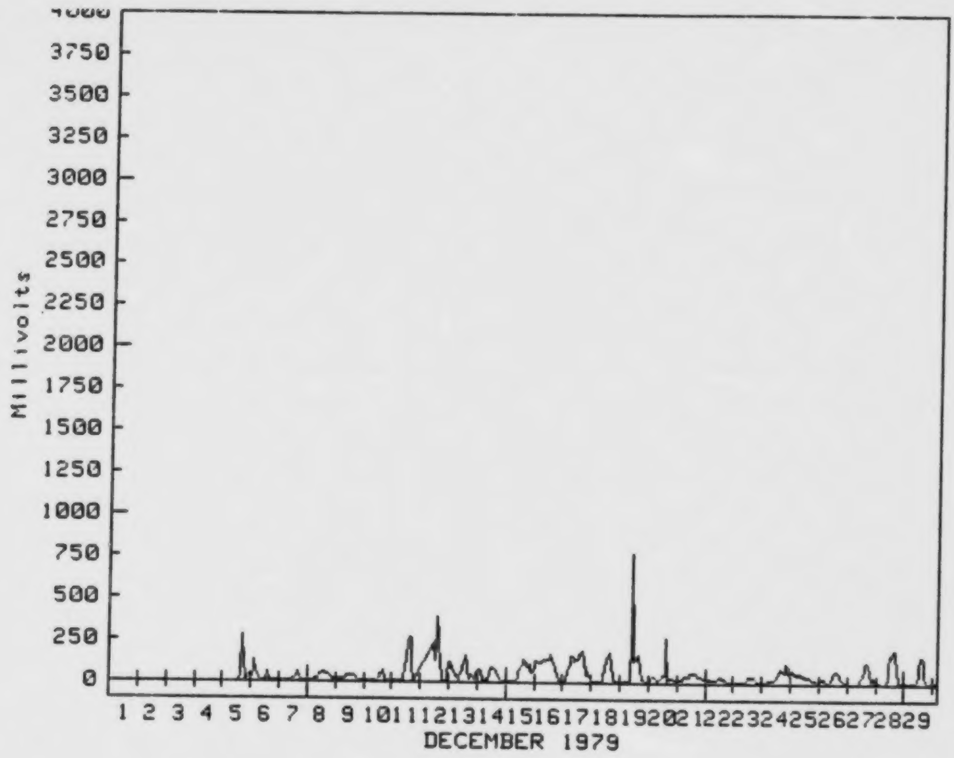

Figure A-11. O_3 air-monitoring data from 7-day operational test of station no. 062042 (Ashland Co., OH).

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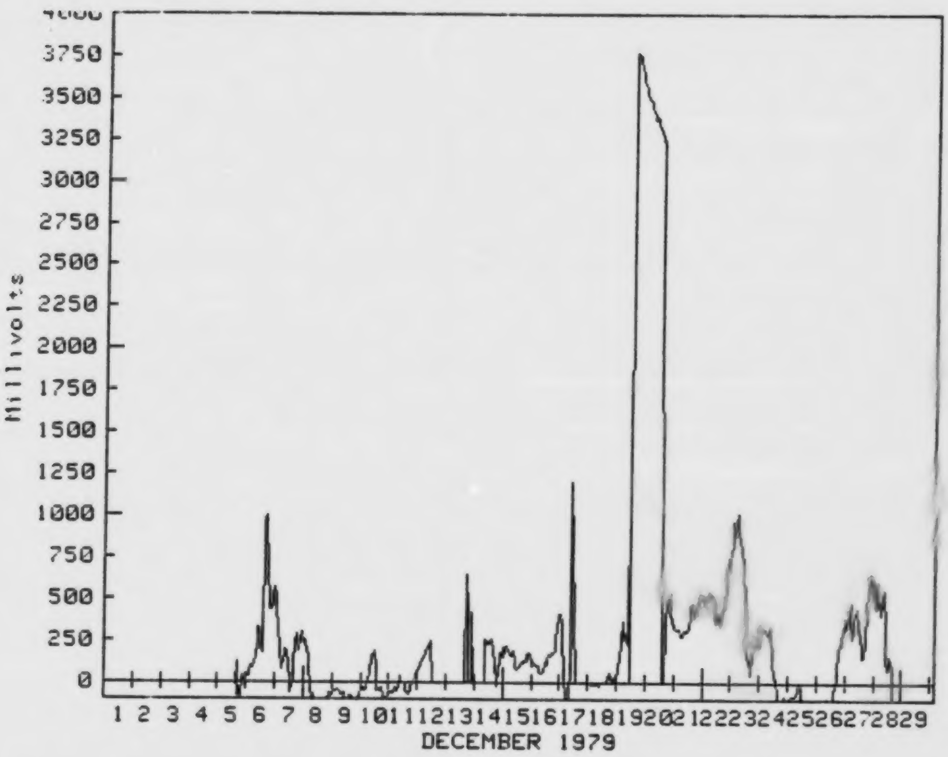

MISSING RECORDS:

791212-791218 turned off for repair of electric calibration motor

Figure A-12. Nephelometer air-monitoring data for 7-day operational test of station no. 062042 (Ashland Co., OH).

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TABLE A-9. NO, NO_x, AND NO_2 CALIBRATION AND AUDIT DATA FOR STATION NO. 062126 (UNION CO., KY)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800118*	NO	0	-0.5	--	944	751
	NO_x	0	-0.7	--		772
	NO_2		-0.3	--		
	NO	95.0	95.7	0.7		
	NO_x	95.0	96.0	1.1		
	NO_2	0	0.4	--		
		(UV lamp on)				
	NO	19.0	19.6	3.2		
	NO_x	95.0	92.5	-2.6		
	NO_2	76.0	72.9	-3.1		
800122†	NO	0	0.2	--	944	751
	NO_x	0	-0.3	--		772
	NO_2	0	0.3	--		
	NO	95.0	94.2	-1.0		
	NO_x	95.0	95.5	0.5		
	NO_2	0	0.9	--		
		(UV lamp on)				
	NO	17.0	16.2	-4.7		
	NO_x	95.0	91.4	-3.8		
	NO_2	78.0	77.5	0.6		
800123*	NO	0	1.1	--	944	751
	NO_x	0	-0.2	--		772
	NO_2	0	-0.3	--		

---

*Calibration.
†Audit.

(continued)

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[PREVIOUSLY CIN. EPA FORM 287]
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TABLE A-9 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800123* (cont'd)	NO	95.0	93.8	-1.3		
	NO_x	95.0	94.4	-0.6		
	NO_2	0	0.5	--		
		(UV lamp on)				
	NO	18.0	17.8	-1.1		
	NO_x	95.0	90.2	-5.1		
	NO_2	77.0	72.8	-5.5		
	NO	50.4	49.8	-1.2		
	NO_x	95.0	92.7	-2.4		
	NO_2	44.6	42.8	-4.0		
	NO	84.1	83.0	-1.3	944	751
	NO_x	95.0	94.2	-0.8		772
	NO_2	10.9	12.1	11.0		
800124*	NO	0	-0.4	--	920	782
	NO_x	0	0.5	--		808
	NO_2	0	0.9	--		
	NO	95.0	94.5	-0.5		
	NO_x	95.0	94.8	-0.2		
	NO_2	0	0.3	--		
		(UV lamp on)				
	NO	12.7	12.6	-0.8		
	NO_x	95.0	95.4	0.4		
	NO_2	82.3	81.3	-1.2		

---

*Calibration.

(continued)

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TABLE A-9 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800125†	NO	0	0.3	--	920	782
	NO_x	0	0.7	--		808
	NO_2	0	0.4	--		
	NO	95.0	94.4	-0.6		
	NO_x	95.0	95.6	0.6		
	NO_2	0		--		
		(UV lamp on)				
	NO	13.6	13.8	-1.5		
	NO_x	95.0	94.6	-0.4		
	NO_2	81.4	80.4	1.2		
800128*	NO	0	-1.3	--	922	786
	NO_x	0	-0.1	--		800
	NO_2	0	0	--		
	NO	95.0	95.0	0		
	NO_x	95.0	96.0	1.0		
	NO_2	0	1.6	--		
		(UV lamp on)				
	NO	10.4	9.2	-11.5		
	NO_x	95.0	95.4	0.4		
	NO_2	84.6	85.1	-0.5		
800206*	NO	0	0.7	--	908	738
	NO_x	0	0.8	--		758
	NO_2	0	0	--		

---

*Calibration.
†Audit.

(continued)

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TABLE A-9 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800206* (cont'd)	NO	95.0	94.9	-0.1		
	NO$_x$	95.0	95.2	0.2		
	NO$_2$	0	0.2	--		
		(UV lamp on)				
	NO	15.0	15.0	0		
	NO$_x$	95.0	91.8	-3.3		
	NO$_2$	80.0	78.0	2.5		
800213*	NO	0	0	--	918	736
	NO$_x$	0	0.9	--		759
	NO$_2$	0	0.7	--		
	NO	95.0	95.0	0		
	NO$_x$	95.0	95.0	0		
	NO$_2$	0	0.3	--		
		(UV lamp on)				
	NO	25.5	25.5	0		
	NO$_x$	95.0	95.9	0.9		
	NO$_2$	69.5	68.9	-0.8		
	NO	53.0	53.0	0		
	NO$_x$	95.0	94.4	-0.6		
	NO$_2$	42.0	42.6	1.4		
	NO	84.0	84.0	0		
	NO$_x$	95.0	96.7	1.8		
	NO$_2$	11.0	14.0	27.3		

---

*Calibration.

(continued)

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TABLE A-9 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800215†	NO	0	-1.0	--	918	736
	NO_x	0	-0.1	--		759
	NO_2	0	0	--		
	NO	95.0	93.5	1.6		
	NO_x	95.0	95.0	0		
	NO_2	0	0.9	--		
		(UV lamp on)				
	NO	27.0	25.9	4.1	918	736
	NO_x	95.0	95.5	0.5		759
	NO_2	68.0	68.3	0.4		
800219†	NO	0	-0.5	--	918	736
	NO_x	0	0.9	--		759
	NO_2	0	0.4	--		
	NO	95.0	97.2	2.3		
	NO_x	95.0	97.2	2.3		
	NO_2	0	-0.1	--		
	NO	26.1	26.3	0.8		
	NO_x	95.0	96.2	1.2		
	NO_2	68.9	68.3	0.9		
800222†	NO	0	-5.3	--	922	786
	NO_x	0	-3.5	--		800
	NO_2	0	0.9	--		
	NO	95.0	94.1	0.9		
	NO_x	95.0	94.4	0.6		
	NO_2	0	0.3	--		

---

†Audit.

(continued)

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TABLE A-9 (continued)

Date	Pollutant	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800222† (cont'd)		(UV lamp on)				
	NO	28.6	24.6	14.0		
	NO_x	95.0	97.2	2.3		
	NO_2	66.4	72.1	8.5		

†Audit.

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TABLE A-10. O_3 CALIBRATION AND AUDIT DATA FOR STATION NO. 062126 (UNION CO., KY)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800118*	0	-0.005	--	010	352
	76.0	75.0	-1.3		
800122†	0	0	--	010	352
	78.0	77.5	-0.6		
800124†	0	0.4	--	010	352
	81.3	84.8	4.3		
800125†	0	0.7	--	010	352
	81.4	81.1	0.4		
800128†	0	-1.5	--	011	354
	84.7	85.1	0.5		
800206*	0	0	--	010	361
	80.6	80.0	-0.7		
800213†	0	0.8	--	010	361

*Calibration.
†Audit.

TABLE A-11. TOTAL SULFUR CALIBRATION AND AUDIT DATA FOR STATION NO. 062126 (UNION CO., KY)

Date	Concentration (ppb)	Response (ppb)	% Difference	Zero Pot	Span Pot
800118*	0	-0.4	--	055	733
	84.0	83.5	0.5		
800122†	0	-2.0	--	055	733
	84.0	85.0	1.2		
	52.0	55.0	5.8		
	35.0	36.4	4.0		
	22.0	20.0	-10.0		
800123†	0	0.3	--	055	733
	84.0	85.1	1.3		
800124†	0	0	down	055	733
	84.0	84.8	1.0		
800125†	0	-1.6	--	055	733
	84.0	85.1	1.3		
800128*	0	-1.5	--	136	733
	84.0	82.0	-2.4		
800206†	0	2.3	--	353	511
	84.0	83.6	-0.5		
	52.0	51.2	-1.5		
	35.0	34.6	-1.1		
	22.0	23.2	5.5		
800215†	0	0.8	--	353	511
	84.0	85.5	1.8		
800219*	0	-0.7	--	353	511
	84.0	83.6	-0.5		

*Calibration.
†Audit.

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TABLE A-12. NEPHELOMETER CALIBRATION AND AUDIT DATA FOR STATION NO. 062126 (UNION CO., KY)

Date	Electric Zero (volts)	Air Zero (volts)	Electric Cal. (volts)	Freon (volts)
800118*	-0.012	-0.018	3.987	
800122*	0.011	-0.035	4.167	1.185
800123†	0.008	-0.015	3.947	
800124†	0.007	-0.018	3.997	
800125†	0.004	-0.011	3.899	
800128†	0.001	-0.015	3.922	1.184
800206†	0.003	0.004	3.812	
800211†	0.013	0.004	4.175	
800213*	-0.006	0.040	3.817	1.171
800215†	0.008	0.022	4.101	
800219*	-0.021	-0.006	4.132	1.283
800222†	0.001	0.003	4.711	1.299

*Calibration.
†Audit.

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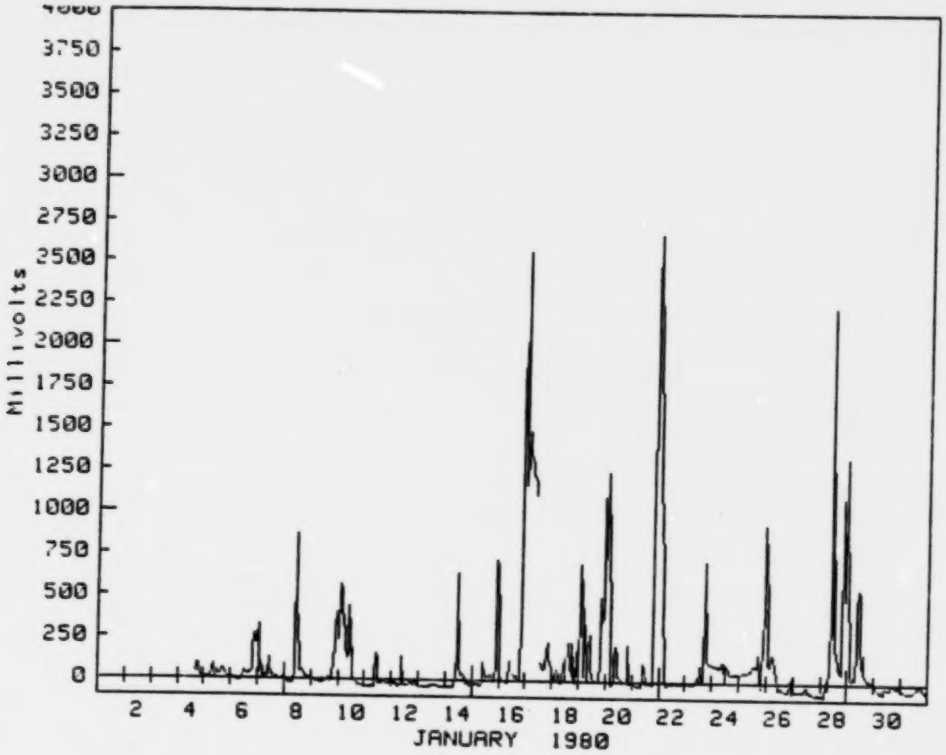

MISSING RECORDS:

8001170900 training Mead group

Figure A-13. NO air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).

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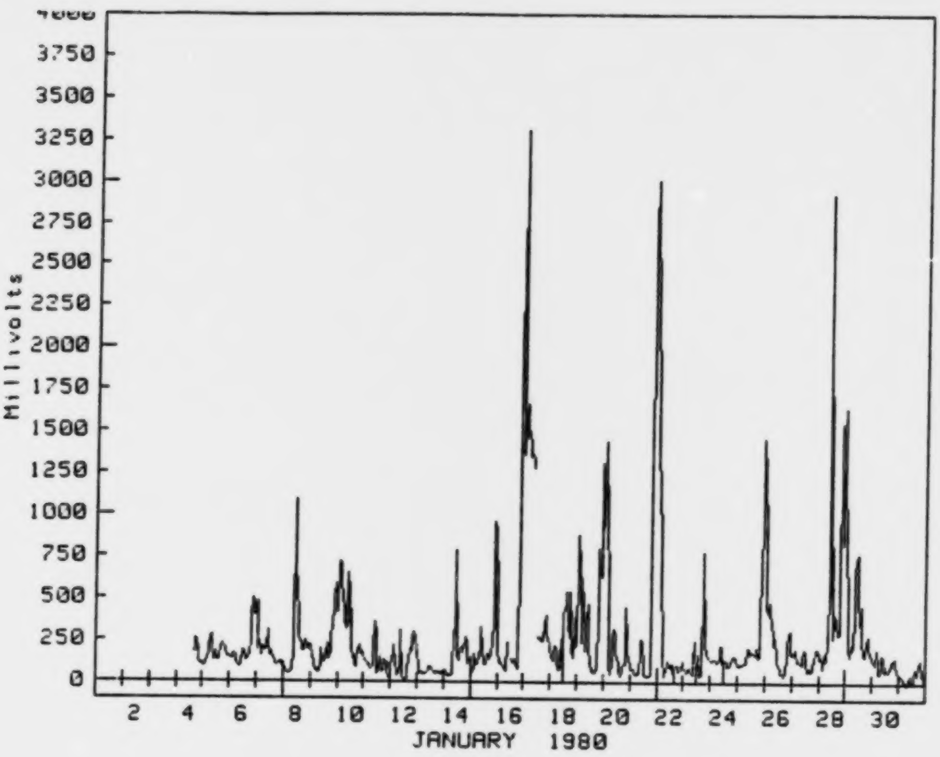

Figure A-14. Total NO_x air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).

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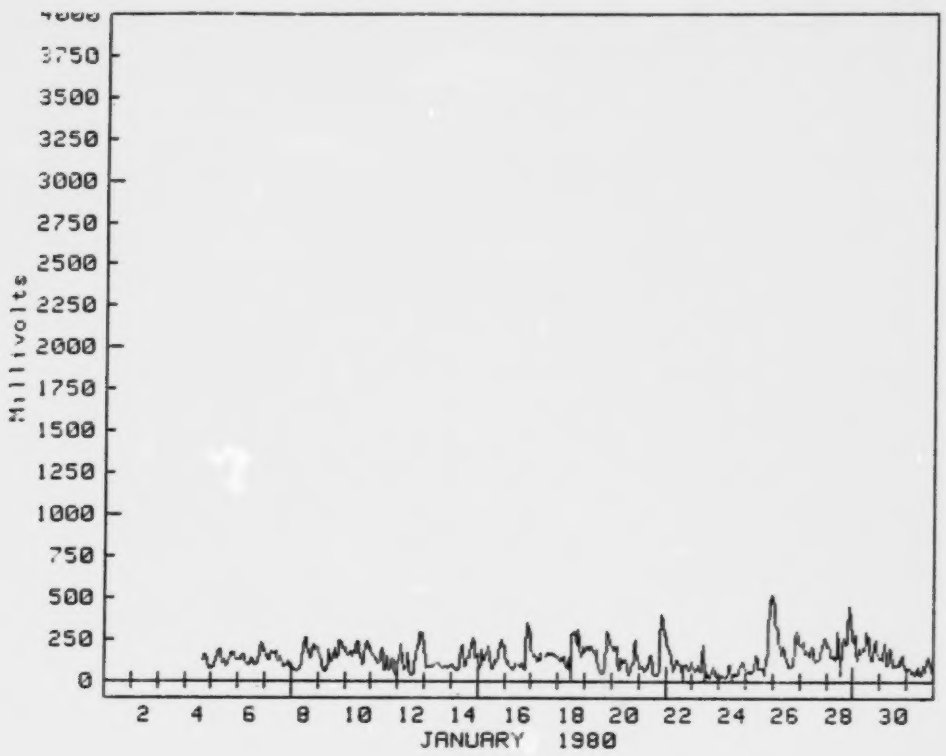
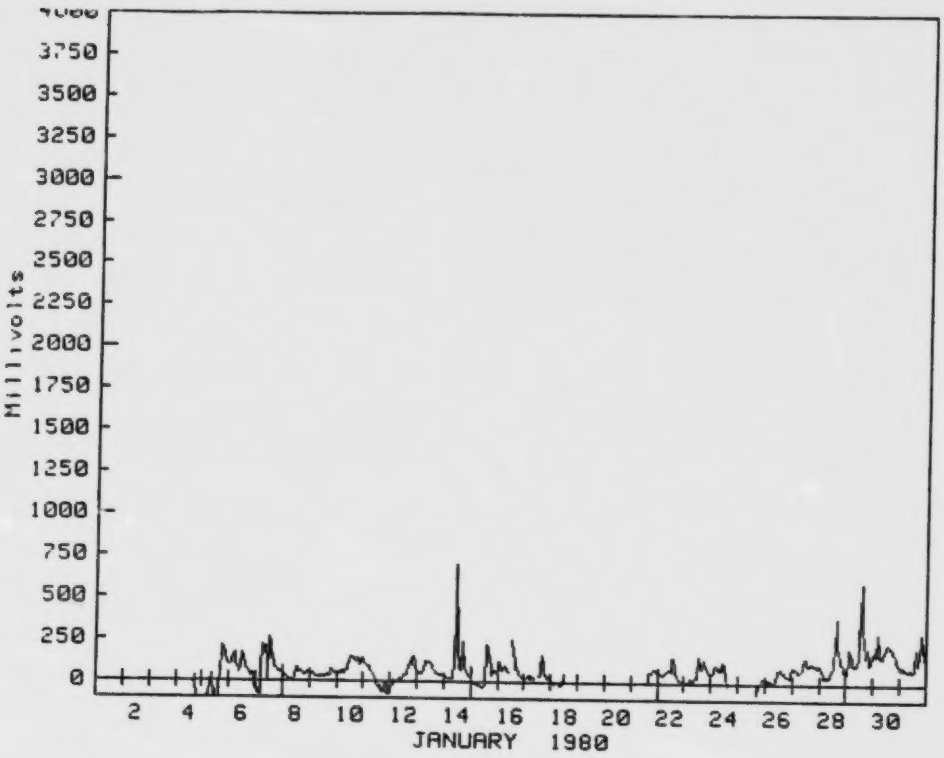


Figure A-15. NO_2 air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).



MISSING RECORDS:

800118 training Mead group

8001241400-8001251800 broke a fitting while changing H_2 tank

Figure A-16. Total sulfur air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).

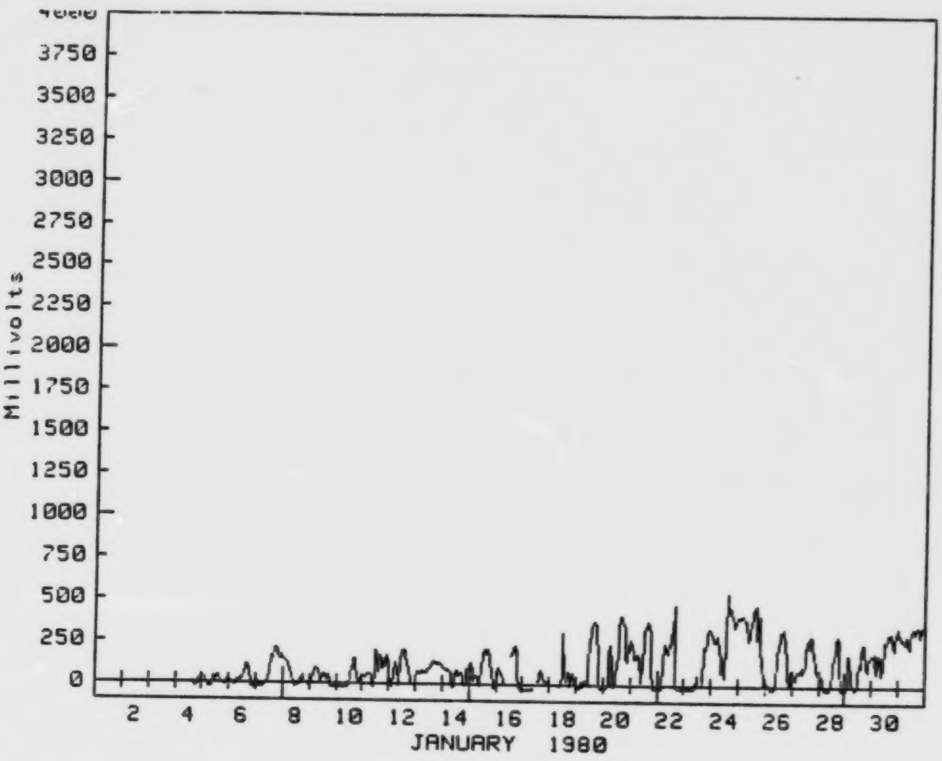


Figure A-17. O_3 air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).

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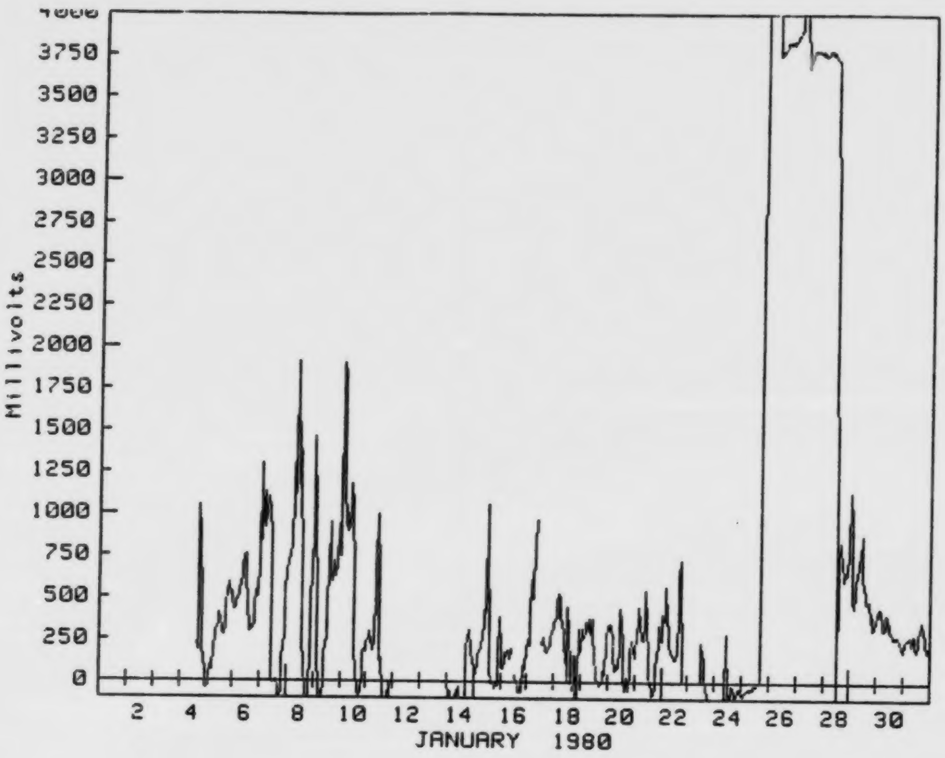

MISSING RECORDS:

800111-800114 drifted below 0 ≅ 0.5 volts

800117 training Mead group

8001221800-8001231200 isolated by operator

Figure A-18. Nephelometer air-monitoring data from 7-day operational test of station no. 062126 (Union Co., KY).

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NSI Environmental Sciences ES-TR-81-06

November 1979

ORBS STATION OPERATION MANUAL

by

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FOR INTERNAL USE ONLY

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ABSTRACT

This manual, in conjunction with manufacturers' instrument manuals, is intended to serve as a source of information on the operation and maintenance of Ohio River Basin Study (ORBS) air quality monitoring stations. The manual includes information about the station shelters, air conditioning and heating units, and all analytical instruments, as well as operation and maintenance instructions and references to equipment information contained in the manufacturers' manuals.

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2	Station Description	3
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4	Cold Startup	17
5	Maintenance	23

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SECTION 1

INTRODUCTION

The purpose of this manual is to provide the station operator with a basic outline for the operation and maintenance of ORBS air quality monitoring stations. The manual contains a compilation of relevant information from the manufacturers' manuals and a set of suggested instrument operation instructions. Manufacturers' manuals should be consulted whenever a problem not discussed in the manual is encountered.

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SECTION 2

STATION DESCRIPTION

The three ORBS stations described in this manual are constructed in essentially the same manner. Each station consists of an air conditioned shelter, a special heated sample inlet system, aerosol inlets, air quality measurement instrumentation, and a data acquisition system.

SHELTERS

The shelter dimensions at all stations are 4.88 m x 3.25 m x 2.74 m. The shelter walls are constructed of interlocking steel panels. Both the walls and the ceiling are insulated. The shelter has two doors; one secured with a sliding bolt, the other with a keyed dead bolt lock. The roof is flat and covered by an expanded metal grating which can easily support 800 lbs of personnel and equipment. Power receptacles and openings for routing signal lines are located on the side of the shelter close to the roof. A portable aluminum ladder is used to reach the roof. The structural steel base of the shelter has four lifting lugs for moving the station. The shelter weighs approximately 6800 lbs. Three standard 19-in wide instrument racks, fastened securely to the floor, are located directly below the heated sample inlet system.

The station power requirements are satisfied by 100-amp, 120/240 V, three-wire, single phase service. The power is distributed through a 20-circuit capacity power distribution panel with 20-amp circuit breakers. The 240-V air conditioning/heating circuit is protected by a 70-amp, double-pole circuit breaker.

Voltage to the four twist-lok type power outlets (on the ceiling over the instrument racks) is regulated by a Sola CVS23-25-230-3 constant voltage transformer (Sola, 1717 Busse Rd., Elk Grove Village, IL) to within ± 0.5 percent for an input range of ± 15 percent of nominal voltage. Each of these power outlets has its own set of circuit breakers which are mounted in a box on the wall close to the main circuit breaker box. The instruments are supplied with the regulated power by means of strips in the racks which are plugged into the sockets overhead.

Interior lighting is provided by six 4-ft ceiling-mounted fluorescent fixtures. A photoswitch controlled incandescent lamp illuminates the area outside the station door.

Four automatic fire extinguishers (Noxfire Freon 1301, Noxfire Division, Star Sprinkler Corp., Philadelphia, PA) are mounted on the ceiling. Their temperature sensitive sprinkler heads are set to open at 165°F (74°C). They are disposable, and once activated must be discarded and replaced.

A wall-mounted central air conditioning and heating system (Bard Manufacturing Company, P.O. Box 607, Bryan, OH, Model 48WA2-10), along with a galvanized sheet metal duct system equipped with fittings, dampers, and registers, provides temperature control inside the station. The air conditioner has a 47,000-BTU cooling capacity. The electric resistance heat strips mounted inside the air circulation system have a 34,130-BTU capacity. This system is adequate for maintaining an interior temperature of 70°F ± 3°F (21°C + 1.7°C), within an outside temperature range of 0°F to 90°F (-18°C to 32°C). The wall-mounted thermostat has separate setting adjustment levers for heating and cooling, allowing either mode to operate depending on temperature conditions.

SAMPLE INLET SYSTEM

The dichotomous sampler and the integrating nephelometer use particulate sample inlets. Each instrument has its own inlet, which consists of a vertical aluminum pipe 1½ in o.d. and 1 in i.d., with a 15-μm cutpoint sampling head at the inlet designed to keep out insects and rain.

The gas instrument inlets are ten-foot long, ¼-in o.d. Teflon lines placed inside heated sheaths (Technical Heaters, 710 Jessie St., San Fernando, CA 91340 (213) 361-7185) to prevent condensation. There is one sheath for each station with two lines per instrument. One line serves as a sample inlet line, the other as a calibration line. A 110-V electric heating element and a thermocouple are located inside the sheath beside the tubing. Both elements are connected to a proportional controller which maintains the line temperature at 100°F (38°C). This temperature is well above the highest anticipated ambient sample dew point, ensuring that no condensation and attendant sample degradation can occur. A Teflon tee and a Teflon filter are attached to each pair of lines outdoors at the opposite end from the instrument.

The heated line sheaths pass inside a 3-in i.d. glass Kimax Process Pipe sampling cane down through the shelter roof to each instrument. The filters and tees are protected from the weather by an inverted glass funnel attached to the cane. The sample inlet is located 1.1 m above the shelter roof (4 m above ground). Inside the station, the ¼-in inlet line for sampling is connected to the instrument and the other line, used for calibration, is capped. Outside the station, the calibration line is connected to a Teflon tee (see Figure 1). The sample line is connected to a Teflon in-line filter, which in turn is connected to the same tee. The third branch of the tee is open to the atmosphere for sampling purposes, or serves as a calibration gas vent for excess calibration gas. This arrangement allows calibration gas to pass through the entire ambient sample inlet system.

COMPRESSED GAS FACILITIES

Gas cylinders can be stored either inside the station in a well-ventilated cylinder closet, or outdoors close to the closet wall. Lines from both locations pass through the closet to the instrument racks. Flammable gases such as hydrogen and ethylene must be kept outside.

INSTRUMENTS

The air quality monitoring instruments installed in each station are listed in Table 1. A brief discussion of each instrument is included here for operator orientation. However, the manufacturers' manuals should be consulted for more complete information.

Gaseous Sulfur Analyzer

The concentration of gaseous sulfur compounds in the atmosphere is monitored using a Meloy Model SA285E Sulfur Dioxide Analyzer, operated without the hydrogen sulfide (H_2S) scrubber. The ORBS model is not equipped with any of the available factory options. The instrument uses a flame photometric detector (FPD), which is both sensitive to and selective for sulfur compounds. A sample flow of 250 cc/min is introduced continuously into a hydrogen-rich flame. Sulfur compounds are converted by the flame to an excited S_2 reaction intermediate, which emits light as it decays to a lower energy state. The intensity of this emission is measured using a photomultiplier tube, along with a 394-nm narrow band pass filter for improved selectivity. Sample flow is regulated using a vacuum pump and a critical orifice maintained at the burner block temperature of 150°C. Hydrogen flow is regulated using a flow restrictor housed in the detector oven, which is maintanied at 20°C by a thermoelectric cooler. This flow restrictor capillary, in conjunction with a special hydrogen pressure regulator mounted inside the instrument, maintains the hydrogen flow at 125 cc/min.

The electronic functions carried out in the analyzer are FPD signal processing, temperature control of the FPD burner block and the photomultiplier tube assembly,and provision of low and high voltage power. FPD signal processing is required because sulfur concentration is proportional to the detector signal raised to a power slightly greater than 0.5. This exponentiation process is carried out electronically by first multiplying the log of the signal by the exponent and then taking the antilog of the product. This processed signal is then directly proportional to sulfur concentration.

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The instrument has four ranges and three time constants from which to choose. The most sensitive is 50 ppb full scale. The instrument's power requirements are 115 V, 50/60 Hz, 250 W. The hydrogen requirement is 125 scc/min at 45 to 60 psig. A size 200 cylinder lasts 3 to 4 weeks at this rate.

Nitrogen Oxides Analyzer

Nitric oxide (NO) and nitrogen dioxide (NO_2) are measured by a Columbia Scientific Industries Oxides of Nitrogen Analyzer, CSI Series 1600. NO is detected by measuring the light emitted by the flameless chemiluminescent reaction of NO with ozone (O_3). The reaction occurs in a reaction chamber thermostatted at 50°C for added stability during changes in ambient temperature. The photomultiplier tube is thermoelectrically cooled to 10°C to reduce dark current.

The detector does not respond to NO_2. NO_2 is measured by conversion to NO, followed by chemiluminescent reaction with O_3. When the sample passes through the converter, the output contains both the NO originally present and the NO produced by the conversion of NO_2 to NO. This sum is detected and called NO_x. The NO_2 concentration is calculated by subtracting NO from NO_x. These two measurements are taken using a single detector. A valve switches the converter in and out of the stream every 15 sec, thus providing both a NO and a NO_x signal. A cam on the valve activates a switch, which switches the electrometer output between two sample-and-hold circuits whenever the converter is switched. Thus it provides continuously available signals for NO and NO_x.

The sample air flow rate of 400 to 600 cc/min and the ozone flow rate of 125 cc/min are maintained by two capillaries thermostatted at 50°C in the reaction chamber oven. Flow is maintained by a pump located downstream from the capillaries.

The instrument has seven ranges extending from 50 ppb full scale to 5 ppm full scale. An integration time constant of 5 sec, 15 sec, or 60 sec can be chosen.

Support requirements include a dryer for the ozone generator supply air. A plastic Drierite cannister is used. This cannister will be exhausted after 30 days operation at 50 percent relative humidity. The electrical requirements are 105 to 125 V, 60 Hz, 500 W.

Ozone Analyzer

Ozone is measured using a Bendix Model 8002 Ozone Analyzer. The ozone detection process involves measurement of light emitted during the flameless chemiluminescent reaction between ozone and ethylene. Ethylene and the ambient air sample are drawn into the instrument continuously and mixed in a chamber. The chamber has an optical window and a photomultiplier tube for measuring the intensity of the light emitted. Since ethylene is present in excess, the light intensity is directly proportional to the ozone concentration. The photomultiplier is thermoelectrically cooled to 5°C to lower dark current and improve the detection limit. The signal from the photomultiplier is amplified and routed to both a front panel meter and terminals at the front and rear of the instrument.

A vacuum pump draws sample air and ethylene into the reaction chamber. The ethylene flow is regulated by a pressure regulator and capillary restriction. The air flow is regulated by a needle valve between the pump and the chamber. This flow is measured by a flowmeter located on the front panel.

Seven ranges can be selected from the front panel; the lowest is 10 ppb ozone, and the highest is 1 ppm ozone. One of three time constants (1 sec, 10 sec, and 40 sec) can be chosen. The power requirements are 105 to 125 V, 60 Hz, 350 W. A regulator and cylinder of CP-grade ethylene are also required. One cylinder should last 6 to 8 months.

The ozone analyzer has internal zero and span capability. Zero air is provided by passing ambient air through a chemical filter mounted on the rear panel, which removes ozone and water vapor. Span calibration is provided by passing zero air first through a previously calibrated ozone generator mounted

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in the instrument, and then into the reaction chamber. This procedure provides a quick operational check independent of the station calibration system, but is not intended as a substitute for the most reliable method.

Dichotomous Sampler

The Beckman Instruments automated dichotomous sampler collects ambient aerosol through a special aerosol inlet on the station roof and deposits two size fractions on separate 37-mm diameter Teflon membrane type filters. Fine size fraction (respirable) particles have aerodynamic equivalent diameters between 0.01 µm and 2.5 µm. Coarse fraction (non respirable) particles range from 2.5 µm to 15 µm. These two size fractions are collected separately for analysis because they behave differently in the environment. After collection, the loaded filters are removed from the instrument and taken to another laboratory for analysis.

Separation by size inside the instrument is accomplished using a single stage virtual impactor. Coarse particles are impacted directly into a void, whereas fine particles follow the path of the bulk of the air stream as it bends sharply inside the impactor. Both size fractions are then collected on separate Teflon filters.

The automatic filter change mechanism allows unattended operation for up to 36 filter pairs. Timing and the filter changing processes are under microprocessor control. The operator programs the instrument to sample for a given time interval before automatically changing filters. The instrument then runs unattended until all 36 filter pairs have been loaded with particles. Power failures and overloaded filters are sensed and dealt with by the control circuitry.

The sampler power requirement is 115 V, 750 W. Its case is weatherproof and designed for outdoor operation. All ORBS samplers are located indoors for operator convenience, however.

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Integrating Nephelometer

During air pollution episodes visibility is often noticeably reduced. This decrease in visibility is caused by the absorbtion and scattering of light by vapors and particles in the air. The MRI Model 1591 integrating nephelometer measures the light scattering properties of atmospheric samples drawn through the instrument. A bright light illuminates the sample stream, and a photomultiplier tube measures scattered light at a right angle to the light beam. This measurement is made continuously.

The scattering coefficient range within which this instrument operates is $0\text{-}10^{-4}\ m^{-1}$. The power required is 105 to 125 V, 60 Hz, 60 W.

DATA ACQUISITION SYSTEM

The data acquisition system (DAS) samples analog voltage signals from the ORBS instruments and performs analog to digital conversion once each minute. It calculates the average of these signals hourly, and stores these averages on magnetic tape. The number of data points averaged along, with the time and date on which the data were taken, are also stored on magnetic tape. This is accomplished using a HP9825A calculator, an Eastchester interface, and an uninterruptable power supply.

The HP9825A is a desk-top programmable calculator with 6,844 bytes of read/write memory, a 32-character LED display, a 16-character strip printer, and a built-in two track tape cartridge drive. The ORBS installation also includes a 98213A General I/O-Extended I/O ROM, a real-time clock, and a 98032A 16-bit I/O interface. The calculator uses HPL, a high level language designed for scientific and engineering applications. The power required is 120 V, 180 W.

The Eastchester interface has 16 analog input channels. The input range for each channel is -3.999 V to +3.999 V. Once each minute the program sends commands to the interface specifying the channel numbers to be recorded. The

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interface then samples, digitizes, displays and outputs the digital signal for that channel. The interface is housed in its own 3.5-in x 12-in x 11-in cabinet.

The uninterruptable power supply consists of a 12-V battery charger, a 12-V marine lead acid storage battery, and a 12-V to 120-V, 60 Hz inverter. In the event of power failure, the battery charger ceases to provide power, but the inverter is still supplied by the battery. The battery can maintain the DAS power for at least 6 h.

SECTION 3

INSTALLATION

STATION

Station placement and proper connection to utilities should be carried out using normal care and standard procedures. One important nonstandard requirement is the use of two ground rods. The design of the Sola constant voltage transformer requires that in addition to the ground rod bonded to the main service equipment, a second rod bonded to the neutral on the secondary of the sola transformer be installed at least 10 ft from the first rod. The bond on the second rod may be made at the transformer or at the sub panel. The function of the additional ground system is to reduce electrical noise.

INLET SYSTEMS

The aerosol and gas inlet systems should be reinstalled through the roof. The aerosol inlet for the dichotomous sampler is a 114-in aluminum tube with a grey bell-shaped fractionating inlet at the top end. It should be carried to the roof and the lower end then passed through the special weather stripping fitting down into the station. The lower end mates with a short piece of similar tubing by means of a plastic coupling. The short tube passes through the opening in the top of the case of the dichotomous sampler. It should sit against the inlet to the impactor. A large diameter Tygon tube with two hose clamps is used to fasten this end securely.

The nephelometer inlet is similar to the gas inlet, except that the aluminum tube is shorter and the inlet head slips over the top end of the tube and seals with an O-ring. The end inside the station is connected to the nephelometer inlet with a section of two-inch diameter reinforced grey plastic flexible tubing.

Installing the heated gas inlet system involves placing the glass sampling cane with its metal support and heated lines in position and connecting the heated line sheath to the controller. Make sure the support for the glass cane and the glass funnel coupling are secure.

DATA ACQUISITION SYSTEM

Turn the power switches on the HP9825A calculator, the Eastchester interface, the power inverter, and the battery charger to the "off" position. Place the calculator on its metal tray on the left-hand instrument rack. Then place the Eastchester interface on top of it. The 12-V lead acid marine storage battery, the charger, and the inverter can be placed on the floor below. Connect the charger output and the inverter input lines to the battery, and observe proper polarity: plus to plus, minus to minus.

Plug the 16-bit I/O (device 2) into the calculator rear panel slot closest to center. The other end of the I/O cable should be connected to the rear panel of the interface. The real time clock (device 9) belongs in the calculator rear panel socket next to the 16-bit I/O. The signal cables from the instruments are all connected to the interface using a single multipin connector. Insert this connector into the socket at the rear of the interface.

SULFUR ANALYZER

Place the sulfur analyzer in the right-hand instrument rack. The front panel power switch should be turned off. Check for loose pneumatic and electrical connections inside the instrument. If necessary, reset the front panel meter mechanical zero before removing the shorting strap from its terminals. Remove the strap, connect the properly labeled heated sample line to the "SAMPLE DIRECT" rear panel fitting, cap the "SAMPLE INDIRECT" rear panel fitting, and connect the hydrogen line to the "HYDROGEN" rear panel fitting. Leave the hydrogen shut off. The H_2S stripper column is not used. Connect the properly labeled DAS signal line to the rear panel terminal marked

"100 mV". Connect the other DAS lead (ground) to the rear panel terminal marked "GND". Attach one end of the exhaust line to the "EXHAUST" fitting on the instrument rear panel and pass the other end through the opening in the station floor.

NITROGEN OXIDES ANALYZER

Before the instrument can be installed, the pump shipping block must be removed. First remove the bottom cover. Then remove the screw holding the block. After checking for loose pneumatic and electrical connections on the inside and outside of the instrument, put the cover back on and place the instrument in position in the instrument rack. Make sure the main power switch is off. Attach the properly labeled heated sample line to the sample inlet on the rear panel of the instrument. Then attach the blue indicator end of the reserve dryer for the ozone generator air supply to the dry air inlet. Remove the plug from the other end, which contains white 13X molecular sieve, and attach the main dryer using ¼-in o.d. plastic tubing. Connect the exhaust line to the activated charcoal outlet fitting on the rear panel and place the other end of the line through the opening in the station floor. The properly labeled DAS signal lines should then be connected to the terminals marked 1 for NO, NO_x, and NO_2. Finally make the DAS ground connections.

OZONE ANALYZER

Place the ozone analyzer in the instrument rack, making sure the main power switch is off, and connect the proper heated sample inlet line to the "SAMPLE IN" bulkhead connector at the rear of the instrument. Also connect the metal ethylene line to "ETHYLENE INLET." Position the ethylene cylinder securely and attach the regulator, orifice, and metal tubing which leads to the instrument. The Teflon sample filter mentioned in the manufacturer's manual has been installed elsewhere in the sample inlet system and need not be considered here. Make sure the plug has been removed from the inlet to the calibration sample chemical filter. Connect the properly labeled DAS signal line and ground connection to the rear panel signal terminal strip. Attach

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one end of the exhaust line to the "EXHAUST" fitting on the instrument rear panel and pass the other end through the opening in the station floor.

DICHOTOMOUS SAMPLER

Position the sampler beneath the aerosol inlet which was installed earlier in the ceiling beside the cylinder closet. Remove the sampler access door using the key and insert the short section of inlet pipe, small end down, through the opening in the top of the enclosure. The pipe should butt against the fractionating inlet. A short piece of large diameter Tygon tubing and two adjustable hose clamps are used to secure this connection. Tighten the adjustable seal clamp nut just inside the top of the enclosure.

Connect the short lower inlet pipe to the long upper inlet pipe using the plastic coupling. Next, remove the tape which is used inside the instrument to secure the shuttle cam on the underside of the top plate and to secure the shuttle rods. Make sure that the power switch is off, then plug the sampler in. None of the status lights should be lit. If one is illuminated, actuate the power switch to turn the sampler off.

INTEGRATING NEPHELOMETER

Open the instrument front panel doors and remove any packing material present. Next mount the instrument on the wall beneath its aerosol inlet. The separate grey blower box sits close by on the floor. Next connect the bottom end of the aerosol inlet pipe to the inlet at the top of the instrument using flexible hose. The blower box should also be connected using the purge line, the flexible hose, and the electrical cable.

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SECTION 4

COLD STARTUP

Before beginning, all equipment except the dichotomous sampler should be unplugged. Next, the separate controls for heating and air conditioning on the wall thermostat should be set to 70°F and left as close together as possible. The unit should then be switched on. Maximum temperature uniformity is obtained by operating the circulating fan continuously. Table 2 contains typical control settings to aid startup.

SAMPLE INLET

The heated inlet controller should be plugged into the lines, and into an unregulated 110-V power source. It should be turned on and the setting adjusted until the temperature is maintained at 100°F as read off the front panel meter. The light on the front panel will flash when the system is at equilibrium. The Teflon filters at the system inlet should be changed, and any of the associated Swagelok fittings which are loose should be tightened. The system should then be purged with zero air for at least 1 h.

DATA ACQUISITION SYSTEM

Make sure the power switches on the calculator, the inverter, and the battery chargers are at the "off" position. The calculator switch is located on the right side of the cabinet near the back. Next, plug the calculator and the interface into the output socket of the inverter. Then plug the charger into an outlet and turn it on. The charge rate may be high initially, but should eventually drop to 8 amps when the calculator and interface are on. Finally, turn on the inverter.

Insert a fresh data tape into the calculator transport. The words "Data Cartridge" and "Hewlett Packard" face away from the operator. Turn on the calculator. The data acquisition program in file zero of the tape starts automatically with no operator intervention. The calculator will display the date and time continuously with 1-sec updates. Once each minute the DAS scans the 16 input channels and records the voltage readings. These voltages, along with their respective channel numbers, appear rapidly on the calculator display. Once each hour the 1-min readings are averaged and the averages printed and recorded on magnetic tape along with the channel numbers. Verify that these two operations are taking place. Also verify that the time (EST) and date are correct. After all the instruments are operating, verify that the printed averages represent typical front panel readings after conversion to engineering units.

SULFUR ANALYZER

After installation of the sulfur monitor is complete, the hydrogen inlet pressure should be adjusted to 45 psig using the cylinder regulator. All hydrogen connections should be checked for leaks with Snoop before proceeding. Place the "RANGE" switch in the "1000 ppb" position and the "TIME CONSTANT" switch in the "10 SEC" position and turn on the "POWER" switch. The pump should start running and the "POWER" and "IGNITION" switches should light. If this doesen't occur, check the station circuit breakers and the instrument fuses.

Wait 20 min for the burner block to reach operating temperature. Next, while pushing the "IGNITION" button, set the "HYDROGEN" rotameter flow to 5.0. After a few seconds, release the "IGNITION" button. If the flame is lit, the "IGNITION" button lights will be out. If it is not, wait 30 sec and depress the "IGNITION" button for 10 to 20 sec. This step may have to be repeated to purge the air from the hydrogen lines. When the "IGNITION" button light stays out, the instrument is operating. Using a digital voltmeter, verify that the voltage at the rear panel signal connector is the same as that measured by the DAS to within ± 5 mV.

NITROGEN OXIDES ANALYZER

After installation of the NO_x instrument is completed, set the front panel meter mechanical zero. Next depress the "POWER" switch push-button. The lamp above the button should come on. Do NOT turn on the ozone generator power. The instrument must first stabilize for 2 h. Make sure the cooling fans mounted on the rear panel are operating. If not, or if the power indicator is not lit, check to ensure that power is applied. The ozone flow rate should be between 100 and 150 cc/min. The air flow rate should be between 400 and 600 cc/min. An insufficient flow indicates a leak or a plugged capillary. After 5 to 10 min, the cooler and heater indicator lights should be cycling on and off: if they are not lit check for proper power application; if they remain lit check to be sure the fan is operating. Also check the trouble shooting section of the manufacturer's manual. At this point, the inhibit light is flashing because the ozone generator power is off. After 2 h turn on the ozone generator power. Using a digital voltmeter, verify that the voltages at all three rear panel signal connections are the same as those measured by the DAS to within ± 5 mV.

OZONE ANALYZER

After installation on the ozone analyzer is complete, the ethylene inlet pressure should be adjusted to 30 psig using the cylinder regulator. All ethylene connections should be checked for leaks with Snoop before proceeding. Place the "TIME CONSTANT SELECTOR" switch in the "40 SEC" position, the "MODE SELECTOR" switch in the "ZERO" position, and the "FULL SCALE RANGE SELECTOR" in the ".01" position. Turn the "POWER" switch on and verify that the "POWER" light is lit, the fan is operating, and the pump is running. Wait 2 h for system stabilization before proceeding.

Adjust the "SAMPLE PLUS ETHYLENE" needle valve to obtain the flow rate specified on the most recent station calibration data sheet (an indication of 28 mm on the rotameter is typical). Adjust the "ETHYLENE" pressure regulator on the front panel of the instrument to get the pressure which results in an ethylene flow base of 25 cc/min, as measured by connecting a flow meter to

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the diverter valve and operating the "PULL TO TEST" actuator. Record the pressure and adjust the "ZERO" control until the DAS reading is 0.00 V. Verify the DAS reading with a digital voltmeter. They should agree to within ± 5 mV. Set the "FULL SCALE RANGE SELECTOR" to the ".5" position. Place the "MODE SELECTOR" switch in the "SPAN" position. After waiting 15 min for the ozone generator to stabilize, reset the "SPAN" control so that the DAS reads the voltage specified in the most recent station calibration data sheet. Return the "MODE SELECTOR" switch to "AMBIENT". This use of the internal ozone generator is an operational check only and should not be relied on as primary calibration.

DICHOTOMOUS SAMPLER

After installation the sampler must be programmed. The first step in programming is to remove the front panel and turn on the power. The microprocessor then requests the "CALENDAR TIME" (i.e. the current date and time). In response to the "DAY" light, enter a 3-digit Julian date. For "HOUR" enter a 2-digit number between 00 and 23. For "Minute" enter 00-59. The printer will now print the calendar date and time in the following format:

```
        Day   Hour   Minute
   #1   xxx    xx      xx
```

The shuttle and seal mechanisms will automatically go to the home position, and the tray "INDEX ERROR" light will come on. Next the two filter trays are placed in the sampler. Remove the cover over the tray assembly by removing the single screw which fastens it to the top plate. Raise the tray assembly by turning the large carriage release knob counterclockwise against spring tension until the assembly releases (¼ turn) and lifting. Lift the horizontal tray retaining bar after first removing its retaining screw. Insert two trays, keeping the following in mind:

- Orient the tray so that the tray opening, where the filter moves in and out, is facing the impactor, with the lower filter numbers marked on the tray on top (the numbers on the filters themselves should be face down).
- Make sure the filters from the tray labeled coarse will be under the straight side of the impactor (farthest from the enclosure opening).
- Do not set the trays on the thin metal separators; their function is to push laterally, not to lift.
- Exercise caution and, above all, do not force any part of the mechanism. Lower the retaining bar, fasten it with its screw, and lower the tray assembly all the way using the carriage release knob.

Depress the "RESET" button. If the assembly is seated properly, the "INDEX ERROR" light will go out and "START TIME" and "DAY" will light. Press "TRAY ADVANCE", "0," and "2". The tray will then advance to filter two, the first one to be loaded. Filter one is a blank. Enter the time and day sampling is to begin as above. Do the same for "SAMPLE DURATION" (this will be 000 days, 12 h, 00 min) and for "DELAY TIME" (this entry will be all zeros) The standby light will now remain lit until the start time is reached. Replace the tray assembly cover and the enclosure front door. The instrument is now ready for flow calibration.

There are two separate flow paths: the coarse, whose flow is 1.7 l/min; and the fine whose flow is 15.0 l/min. The total is 16.7 l/min (1 m^3/h). Both flows are adjusted using needle valves. To calibrate the instrument, first close the coarse flow needle valve. Then measure the fine flow by removing the inlet pipe coupling outside the enclosure and connecting a flow meter to the short sample inlet pipe. Set the flow to 15 l/min using the fine flow needle valve. Next set the coarse flow to 1.7 l/min using the coarse flow needle valve to set the total flow to 16.7 l/min. Reinstall the sample inlet pipe coupling, and the instrument will be ready for operation.

INTEGRATING NEPHELOMETER

After installation is completed, the instrument and blower box should have a large diameter hose, a smaller Tygon purge line, and an electrical cable running between them. Place a No. 9½ stopper in the intake port at the top of the instrument. Place the "AIR-FREON-OPER" switch in the "AIR" positon and the "ZERO-OPER-CAL" switch in the "OPER" position. Turn on the power and purge the optical assembly for 15 min. Verify that the front panel meter reads zero. Next move the "ZERO-OPER-CAL" switch to "CAL" and check to see that the meter reading is at the "CAL" mark. If these readings are as described, the instrument will be ready to operate after removing the stopper and replacing the intake line. If not, the instrument should be calibrated. Connect the properly labeled DAS signal line to the terminals on the right side of the case. Measure the output voltage with a digital voltmeter and verify that the DAS reading for that channel is the same to within ± 5 mV.

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SECTION 5

MAINTENANCE

Although neither time consuming nor extensive, maintenance requirements for proper operation of the ORBS stations are necessary. A preventive maintenance schedule (Table 3) and a list of suggested spare parts (Table 4) are included at the end of this section. The trouble shooting sections of the manufacturers' manuals should be consulted in the event of unexpected equipment failures.

SHELTER

The heating and air conditioning system has two fiberglass filters which should be inspected monthly and replaced if dirty.

SAMPLE INLET SYSTEM

The Teflon filters at the entrance to the gas sample inlet system should be changed once a week.

DATA ACQUISITION SYSTEM

The electrolyte level in the lead acid storage battery should be checked monthly. Add distilled water as necessary.

SULFUR ANALYZER

The rotameters should be cleaned every 12 months or when the ball sticks. Remove the inlet and outlet lines and flush with a degreasing solvent such as a Freon. The hydrogen regulator inside the instrument should be replaced every

24 months. Be sure to use a replacement purchased from Meloy, since it is a special regulator. The vacuum pump should be rebuilt or replaced every 12 months.

The burner chamber may need cleaning, and the optical window may need replacement if a loss of sensitivity is noted. Proper procedures can be found in Section VI of the manufacturer's manual. The exhaust filter may need changing every 6 months. The dilution air orifice should be cleaned every 12 months. Once every 12 months the chassis ventilating fan should be removed, washed in warm detergent solution, and recoated with Rotron filter oil.

Electronic alignment and adjustment will normally not be required unless the amplifier, burner block, or photomultiplier tube are replaced. The adjustment procedure is described in Section VI of the manufacturer's manual.

NITROGEN OXIDES ANALYZER

The two 7-µm sintered stainless steel filter elements should be replaced every 12 months. The main air drier should be replaced when 90 percent of the blue dessicant has turned pink. Replacement will normally be required every 30 days at 50 percent humidity. If this cartridge is not allowed to become completely exhausted, the reserve drier will never need replacement. The activated charcoal cartridge used to destroy residual ozone in the exhaust gases should be replaced every 60 to 90 days. The entire assembly should be replaced every 12 months. The squirrel cage fan on the rear panel requires oiling every 6 months with 2 drops of SAE 20 weight oil (there are two oil holes). Dust should be cleaned from the instrument every 6 months. The NO_2 to NO converter material should be replaced every 12 months, or sooner if calibration shows decreased converter efficiency. Procedures for replacement of converter material appear in Section 6 of the manufacturer's manual.

OZONE ANALYZER

Ozone analyzer preventive maintenance consists mainly of changing filters. The chemical filter should be changed after 8 h of continuous use, or when the

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silica gel turns pink. The ethylene sintered steel mesh element should be replaced whenever the flow is restricted below the level required for proper operation. Dirt should be removed from the instrument before it accumulates. Trouble shooting procedures are included in Section 5 of the manufacturer's manual.

DICHOTOMOUS SAMPLER

No preventive maintenance is suggested by the manufacturer. Should problems arise, the manual contains an extensive trouble shooting section.

INTEGRATING NEPHELOMETER

The Gelman purge line filter in the clean air line should be replaced weekly. The measurement optics should be cleaned every 6 months. This procedure may be required fairly frequently, depending on the amount of dust in the air. The procedure is described in the manufacturer's manual.

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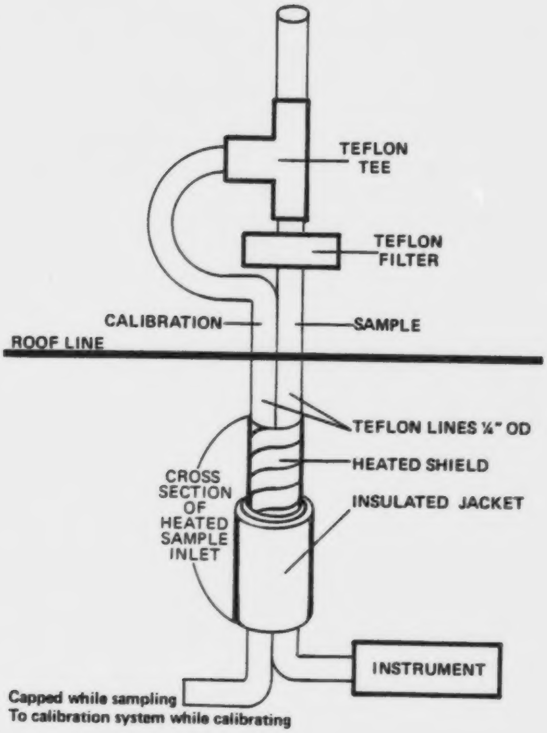
TEFLON TEE
TEFLON FILTER
CALIBRATION
SAMPLE
ROOF LINE
TEFLON LINES ¼" OD
HEATED SHIELD
CROSS SECTION OF HEATED SAMPLE INLET
INSULATED JACKET
INSTRUMENT
Capped while sampling
To calibration system while calibrating

Figure 1. Heated sample inlet system.

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TABLE 1. AIR QUALITY MONITORING INSTRUMENTS LOCATED AT ORBS STATIONS

Manufacturer	Model	Power	Function
Meloy Laboratories, Inc. 6715 Electronic Drive Springfield, VA 22151 (703) 354-2600	285-E	115 V, 250 W	Gaseous sulfur measurement
Columbia Scientific Industries 11950 Jollyville Road Austin, TX 78766 (512) 258-5191	Series 1600	105-125 V, 500 W	Nitrogen oxides measurement
Bendix Process Instruments Post Office Drawer 831 Lewisburg, WV 24901 (304) 647-4358	8002	105-125 V, 350 W	Ozone Measurement
Beckman Instruments, Inc. 2500 Harbor Blvd. Fullerton, CA 92634 (714) 871-4848	Automated Dichotomous Sampler	115 V, 750 W	Particulate collection
Meteorological Research Inc. 464 W. Woodbury Road Altadena, CA 91001 (213) 791-1901	1591 Integrating	105-125 V, 60 W	Scattered light measurement
Hewlett Packard Calculator Products Division Post Office Box 301 Loveland, CO 80537 (303) 667-5000	9825A Calculator	120 V, 180 W	Data acquisition system
Eastchester Corporation 1202 Eastchester Drive High Point, NC 27260 (919) 889-9090		120 V, 20 W	Data acquisition system

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TABLE 2. TYPICAL CONTROL SETTING TO AID STARTUP

Compound	Typical Control (Zero)	Settings (Span)	Range (ppb)
NO	960	480	100
NO_x	960	600	100
SO_2	230	270	100
O_3	0	400	200

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TABLE 3. PREVENTIVE MAINTENANCE CHART

Instrumentation	30 days	60 days	6 months	12 months	24 months
Nitrogen Oxides Analyzer					
Sintered stainless filter elements				REPLACE	
Dessicant	REPLACE				
Activated charcoal		REPLACE			
Activated charcoal assembly				REPLACE	
Squirrel cage fan			OIL		
Fan screen		CLEAN			
Clean dust off instruments			CLEAN		
Converter material				REPLACE	
Sulfur Analyzer					
RotameterS				CLEAN	
Vacuum pump				REBUILD	
H_2 regulator					REPLACE
FPD optical window				REPLACE	
FPD exhaust filter			REPLACE		
Fan air filter				CLEAN	
Nephelometer					
Optics			CLEAN		

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TABLE 4. SUGGESTED SPARE PARTS

Instrumentation	Replacement Part
Shelter	
Air conditioner filters	Fiberglass, 16" x 16" x 1"
Sulfur Analyzer	
FPD exhaust filter	PN S900556
FPD optical window	PN S900659
Vacuum pump repair kit	PN S900745
Hydrogen regulator	PN S900425
Rotron filter oil	
Nitrogen Oxides Analyzer	
Sintered stainless steel filter elements	PN M951-8034
Dessicant	
Converter material	PN M951-8013
Activated charcoal	PN M951-8036
Activated charcoal assembly	PN M01200201
Integrating Nephelometer	
Gelman filters	
Ozone Analyzer	
Chemical filter	PN 5514859-1
Ethylene sintered steel element	PN 006770-1
Data Acquisition System	
Paper tape rolls	

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PAGE NUMBER

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APPENDIX C

STATION AUDIT RESULTS

Northrop Services, Inc. - Environmental Sciences (NSI-ES) audited the ORV stations under EPA Contract 68-02-3285. This appendix consists of two NSI-ES reports submitted to EPA under that contract. The first report (pp. 150-248) summarizes audits performed during May to September 1980; the second report (pp. 249-253) summarizes audits performed during November 1980 to March 1981.

ES-TN-80-11
November 1980

SUMMARY OF AUDITS OF THE OHIO RIVER VALLEY AIR MONITORING STATIONS

by

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Environmental Chemistry and Emissions Research
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Environmental Sciences

Submitted to:

Environmental Sciences Research Laboratory
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Under Contract 68-02-3285

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DISCLAIMER

This report has been reviewed by Northrop Services, Inc. - Environmental Sciences, and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

FOREWORD

This report presents the results of work performed by Northrop Services, Inc. - Environmental Sciences, under Contract 68-02-3285 for the Inorganic Pollutant Analysis Branch, Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, during the period May 23, 1979 to September 26, 1980. Work was completed as of September 26, 1980.

ABSTRACT

Three audits of the Ohio River Valley Air Monitoring Study stations were conducted during the period May 23, 1979 to September 26, 1980. Equipment audited at each station included a Climet meteorological system, dichotomous sampler, high volume sampler, integrating nephelometer, chemiluminescent ozone analyzer, flame photometric total sulfur analyzer, and chemiluminescent oxides of nitrogen analyzer. Each standard and flow measurement device used in the audits was traceable to a Standard Reference Material of the National Bureau of Standards.

Before and after each audit, verification audits were conducted in the facility of the Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA-ORD-RTP).

Results for all three audits are summarized and compared to results of the verification audits. As a basis for discussion, the monitoring stations are assigned grades in accordance with designated performance criteria.

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3 Calibration of Audit Devices and Standards 13

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SECTION 1

INTRODUCTION

The Ohio River Valley (ORV) Study was initiated to measure low level background concentrations of gaseous and particulate pollutants. Northrop Services, Inc. - Environmental Sciences (NSI-ES) designed and constructed the stations and is responsible for external quality assurance. The stations are operated by Mead Technology Laboratories (MTL).

During the period May 23, 1979 to September 26, 1980, NSI-ES conducted 3 performance audits of the ORV stations at bimonthly intervals. The purpose of this series of audits was:

1) To determine the accuracy of individual sensors at given points in time
2) To identify and report in a timely manner each sensor system found to be outside acceptable limits so that MTL could take immediate corrective action

Each standard and flow measurement device used to perform the audits was referenced to a National Bureau of Standards (NBS) Standard Reference Material (SRM) or to a secondary standard traceable to an NBS SRM.

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The stations are located in rural areas near Morganfield, Kentucky; Brookville, Indiana; and Perrysville, Ohio. Two of the stations are on working farms and the third is in a state park. Each station contains a Climet meteorological system that reports wind speed, wind direction, barometric pressure, temperature, dew point, and solar radiation (as measured by an Eppley solar radiometer). The particulate measurement system consists of a Beckman dichotomous sampler, General Metal works high volume sampler, and Meteorology Research Inc. integrating nephelometer. Each station also contains 3 continuous analyzers: a Bendix chemiluminescent ozone analyzer, Meloy flame photometric total sulfur analyzer, and Columbia Scientific chemiluminescent oxides of nitrogen analyzer. Each station also has a gas chromatograph for sampling peroxyacetyl nitrate (PAN) and a high volume sampler with Tenax cartridge system downstream from the particulate filter to sample for organic pollutants.

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SECTION 2

AUDIT DEVICES AND STANDARDS

CONTINUOUS ANALYZERS

Ozone

The chemiluminescent O_3 analyzer was audited using an ultraviolet (UV) photometric calibration system (Figure 1). In this system, the concentration of O_3 in an absorption cell is determined from a measurement of the amount of 254 nm light absorbed by the sample (i.e., the transmittance of the sample):

$$T = I/I_o = e^{-\alpha c l}$$

where c = concentration of O_3

α = absorption coefficient of O_3

l = pathlength

Stable O_3 concentrations were generated with a dynamic dilution/gas phase titration (GPT) system which produces O_3 by UV irradiation of air using a shielded mercury lamp. Upscale concentrations are generated by varying the length of time the lamp is exposed to the air and the total flow of dilution air.

Oxides of Nitrogen

The NO and NO_2 channels were audited using a dilution/GPT system, a cylinder containing 2.95 ppm NO, and a cylinder of zero air used for dilution. The flow rates from the NO cylinder were varied to generate the upscale audit points. The Quality Assurance Division (QAD) of the Environmental Monitoring Systems Laboratory (EPA-ORD-RTP) determined the NO cylinder concentration by referencing to an NBS SRM. All flow rates were measured using a Hastings bubble meter referenced to NBS burettes.

Total Sulfur

The sulfur analyzer was audited using a cylinder containing 2.16 ppm SO_2. Zero air containing ~350 ppm CO_2 was used for dilution. The SO_2 cylinder flow rate was varied to generate upscale audit points. QAD determined the SO_2 cylinder concentration by referencing to an NBS SRM. All flow rates were measured using a Hastings bubble meter referenced to NBS burettes.

DILUTION/GAS PHASE TITRATION AUDIT SYSTEM

The dilution/GPT system is shown in Figure 2. The system is equipped with Tylan mass flow controllers which will maintain mass flow to within ±0.25% of

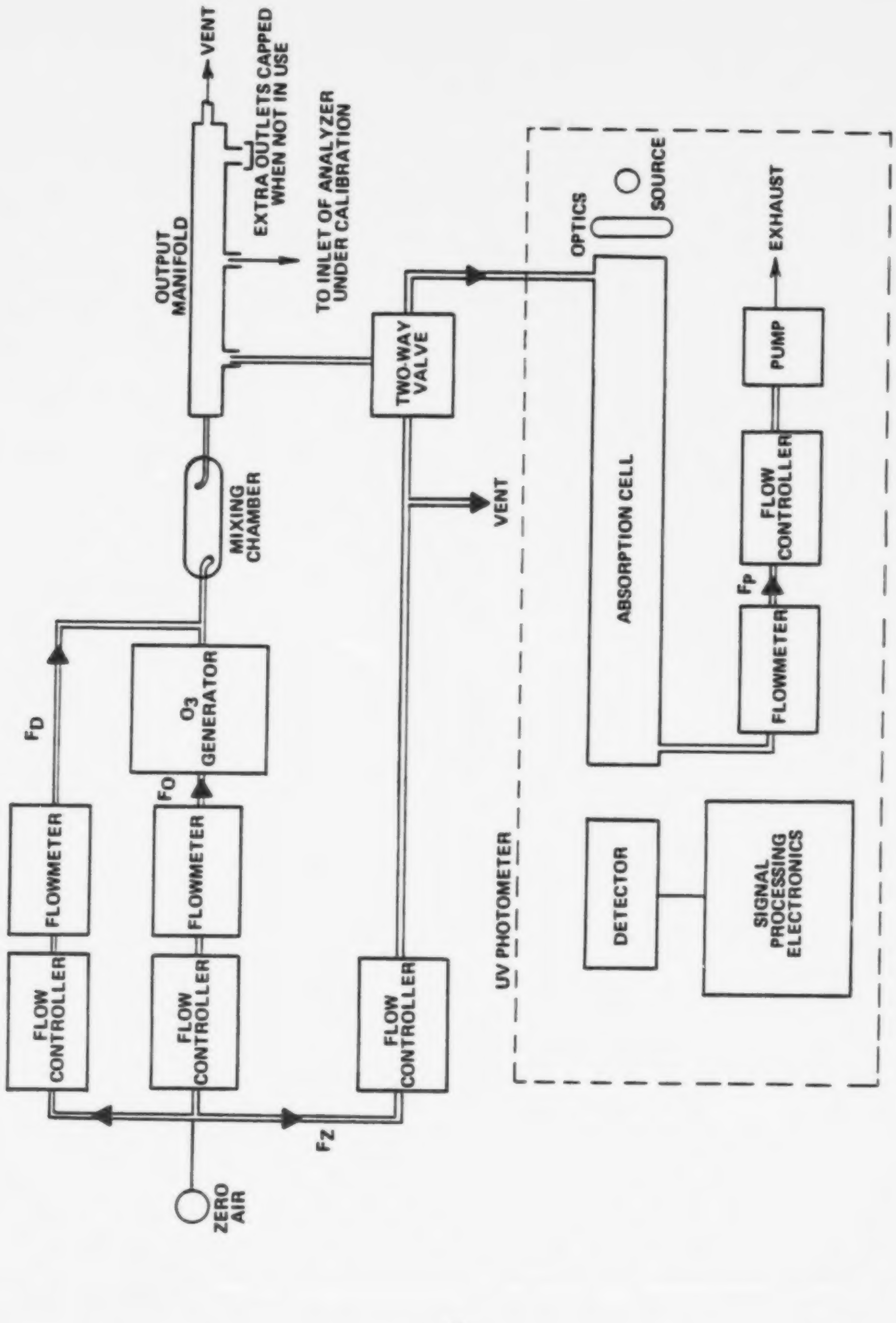
ZERO AIR
FLOW CONTROLLER
FLOWMETER
FLOW CONTROLLER
FLOWMETER
FLOW CONTROLLER
F_D
F_O
F_Z
O_3 GENERATOR
MIXING CHAMBER
OUTPUT MANIFOLD
VENT
EXTRA OUTLETS CAPPED WHEN NOT IN USE
TO INLET OF ANALYZER UNDER CALIBRATION
TWO-WAY VALVE
VENT
UV PHOTOMETER
OPTICS
SOURCE
ABSORPTION CELL
FLOWMETER
F_P
FLOW CONTROLLER
PUMP
EXHAUST
DETECTOR
SIGNAL PROCESSING ELECTRONICS

Figure 1. Schematic diagram of UV photometric calibration system.

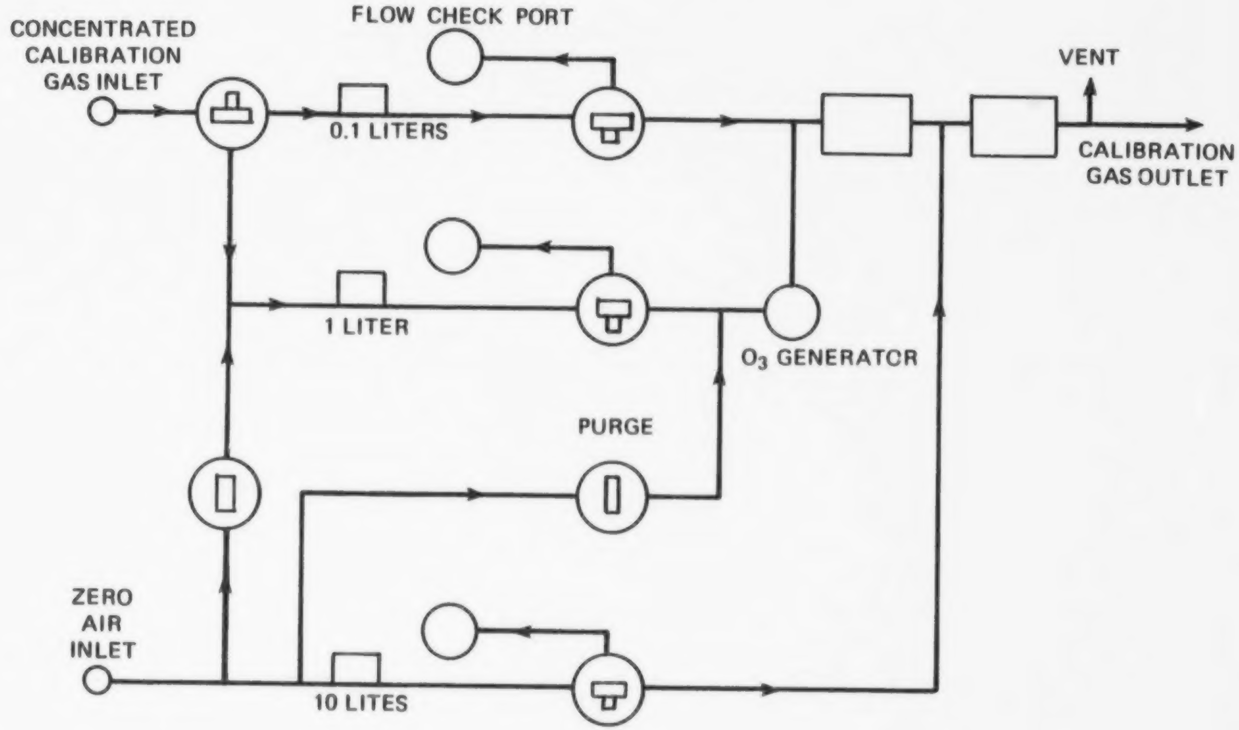
CONCENTRATED
CALIBRATION
GAS INLET
FLOW CHECK PORT
0.1 LITERS
VENT
CALIBRATION
GAS OUTLET
1 LITER
O_3 GENERATOR
PURGE
ZERO
AIR
INLET
10 LITES

Figure 2. Dilution/gas phase titration audit system.

the setting. All fittings and other components which come in contact with oxidizing gases are stainless steel, Teflon, or glass. All flow rates are fully controllable; the dilution airflow, pollutant flow, and flow through the O_3 generators are maintained within the limits described above. Frequent comparisons with QAD have demonstrated the accuracy and stability of the dilution/GPT audit system.

PARTICULATE SAMPLERS

High Volume Sampler

The high volume sampler was audited using an EPA Reference Device (Figure 3). The device consists of a manometer and a mount with interchangeable orifices and a fixed orifice. Flow rate is measured as a function of the pressure drop across the fixed orifice. The interchangeable orifices are used to vary the flow. The standards used to calibrate the Reference Device are a motor driven positive displacement Roots meter and a water manometer.

Dichotomous Sampler

A dry test meter was used to audit the dichotomous sampler. The meter is traceable to an NBS SRM laminar flow element operated and maintained by QAD.

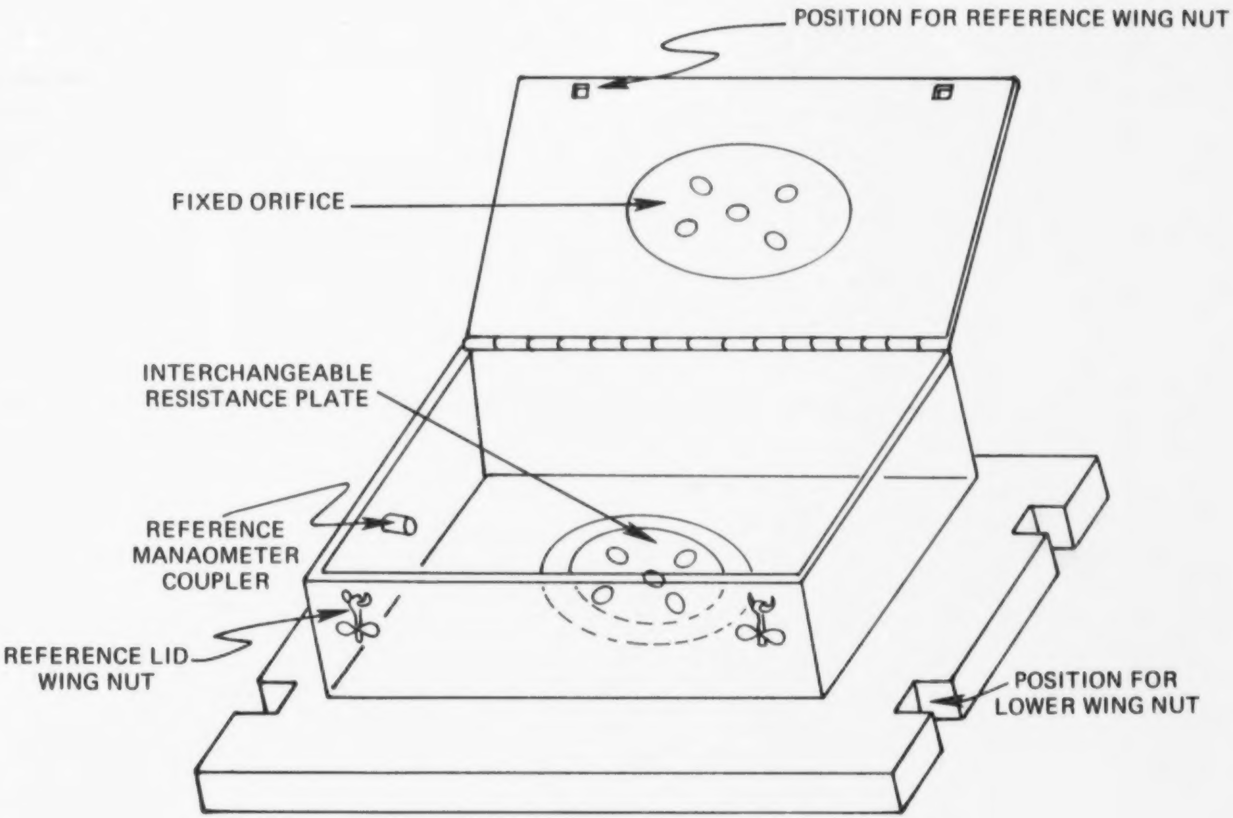
POSITION FOR REFERENCE WING NUT
FIXED ORIFICE
INTERCHANGEABLE RESISTANCE PLATE
REFERENCE MANAOMETER COUPLER
REFERENCE LID WING NUT
POSITION FOR LOWER WING NUT

Figure 3. EPA Reference Device for auditing high volume sampler.

Integrating Nephelometer

The standard used to audit the nephelometer is Freon 12 obtained from a local vendor. Comparisons with other containers from the same and different manufacturers revealed no significant differences measureable with the integrating nephelometer.

METEOROLOGICAL SENSORS

Barometric Pressure

The barometric pressure sensor was audited using a National Semiconductors LX1701A electronic pressure sensor. The standard to which the sensor is traceable is a wall mounted mercury barometer and the local station pressure at Raleigh-Durham Airport.

Dew Point

The dew point sensor was audited using a hand held United States Weather Bureau sling psychrometer.

Temperature

The temperature sensor was audited through reference to the temperature indicated on the dry bulb of the sling psychrometer.

Wind Direction

The wind direction sensor was audited using a system designed by NSI-ES (Figure 4). The system consists of a telescope constructed of nonferrous metal mounted on a leveled platform. A compass is also mounted on the platform, with the bearing indicator aligned parallel to the compass. A circular reticle (calibrated from 0 to 360°) is mounted in the eyepiece. A mirror is mounted at the base of the tower directly under the wind vane. Wind direction is measured by taking a bearing on the tower and adding the number of degrees indicated on the reticle to the compass bearing.

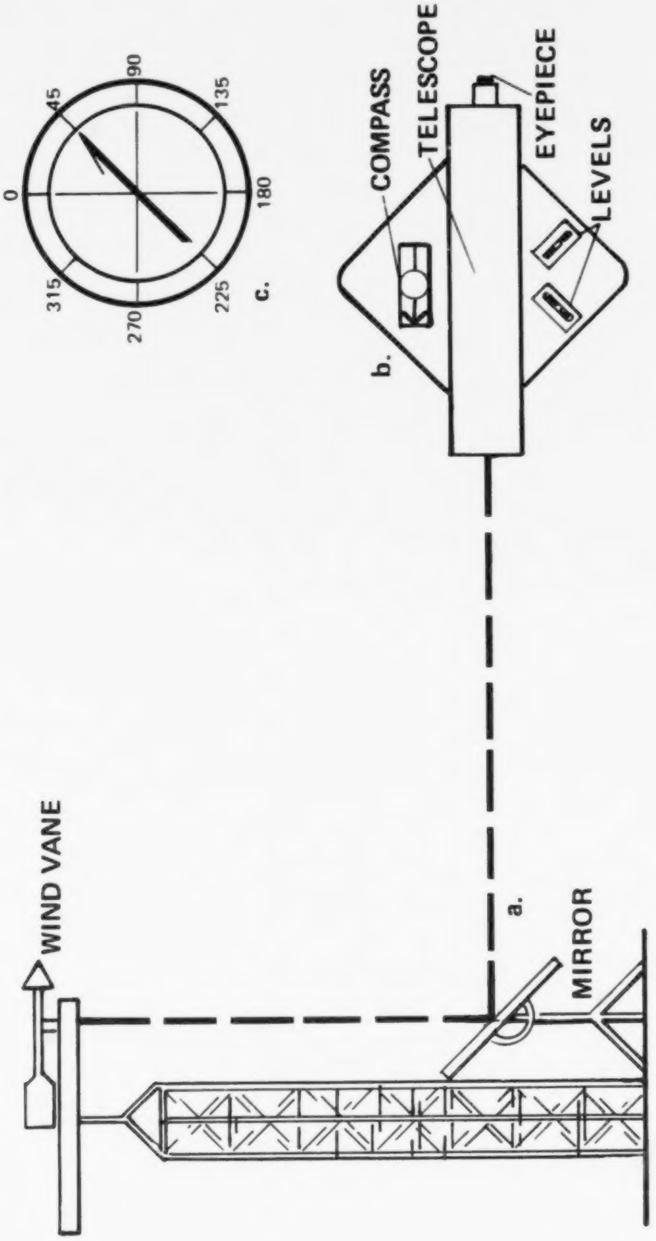
WIND VANE
MIRROR
a.
b.
COMPASS
TELESCOPE
EYEPIECE
LEVELS
c.
0
45
90
135
180
225
270
315

Figure 4. Wind direction audit system.

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SECTION 3

CALIBRATION OF AUDIT DEVICES AND STANDARDS

CONTINUOUS ANALYZERS

Oxides of Nitrogen and Total Sulfur

Compressed gas cylinders were used to generate upscale concentrations of total sulfur and nitrogen oxides. These cylinders were held by the manufacturer until 3 separate analyses (at least one week apart) indicated no degradation. The cylinders were nominally 2.5 ppm in concentration. Following receipt of the cylinders, NSI-ES conducted quarterly analyses of them; traceability to NBS SRM's was maintained in these analyses. Also, cylinder concentration stabilities were confirmed by challenge audit comparisons with QAD before and after each audit.

The mass flow controllers in the dilution/GPT system were calibrated using Hastings bubble meters traceable to NBS SRM burettes. The flow rate of each mass flow controller was measured at 5 upscale points and at zero flow. The reading from the digital indicator and the set point were recorded. Also, during the audit all flows were measured at the exact set point used.

Ozone

The Dasibi O_3 analyzer modified to operate as a UV photometer was calibrated by the following procedure:

1) Onsite, the instrument was allowed to operate until the cell temperature stabilized. With this particular photometer, the cell temperature typically stabilized at ~35°C.

2) The barometric pressure was determined and used to adjust the span number using the following equation:

$$\text{Span number} = \frac{1000\ \text{counts}}{1\ \text{ppm}} \bullet \frac{10^6\ \text{ppm}}{1\ \text{atm}} \bullet$$

$$\frac{1}{2.3026 \bullet 133.9\ \text{cm}^{-1}\text{atm}^{-1} \bullet 71\ \text{cm}} \bullet \frac{760\ \text{torr}}{P} \bullet \frac{T}{273\ \text{K}}$$

where $133.9\ \text{cm}^{-1}\text{atm}^{-1}$ = absorptivity of O_3 at 254 nm

$71\ \text{cm}^{-1}$ = pathlength

P = ambient pressure torr

T = cell temperature (typically ~300 K)

2.3026 = conversion factor between $\log_{10}$ and $\log_e$

This span number provides 1000 counts/ppm or 1 count/ppb. The calculation can be simplified to the equation

$$\text{Span number } 45682 = \frac{760\ \text{torr}}{P} \bullet \frac{T}{273\ \text{K}}$$

3) The solenoid valve was repeatedly checked for leakage from the zero air to span side and vice versa. These checks were performed before and after each audit trip and (if there was a discrepancy) onsite.

4) The flush and sample cycle times were periodically measured to ensure that at least 5 cell volumes flowed through the cell for each cycle.

5) The photometer was periodically pressurized to ~5 lb/in^2 and the internal fittings checked for leaks using a bubble solution.

DILUTION/GAS PHASE TITRATION AUDIT SYSTEM

The mass flow controllers within the dilution/GPT audit system were calibrated using a Hastings bubble meter traceable to NBS burettes. Each flow rate point was measured 3 times and averaged at 5 points over the range of interest; a calibration curve was constructed. In the field, all flow rates were measured at the exact set point used and corrected to 760 mmHg and 25°C.

PARTICULATE SAMPLERS

High Volume Sampler

Before each audit trip, QAD calibrated the EPA Reference Device (Figure 2) using a positive displacement Roots meter and water manometer. The Roots meter is annually referenced to a primary standard by NBS. The Reference Device was calibrated by inserting the 13 hole orifice, varying the flow (hence the pressure drop across the fixed orifice), varying the revolutions per minute of the Roots meter, and measuring the pressure change indicated. This was done at 5 different flow rates across the normal range for the high volume sampler.

The procedure was repeated 3 times and the linear regression of best fit and confidence intervals calculated.

Dichotomous Sampler

The Singer dry test meter used to audit the dichotomous sampler flow rates was calibrated by QAD using an NBS laminar flow element. At each measurement point, 3 repetitions of 5 rotations of the meter were made and linear regression and confidence intervals calculated.

METEOROLOGICAL SENSORS

Barometric Pressure

The electronic barometer used to audit the barometric pressure sensor was calibrated through reference to a mercury barometer and to the Raleigh-Durham Airport local station pressure. Calibration was performed before and after each audit trip.

Temperature and Dew Point

The thermometers of the sling psychrometer were calibrated through reference to a certified thermometer.

Wind Direction

Wind direction was measured by a compass indicating magnetic North.

SECTION 4

VERIFICATION OF AUDIT DEVICES, STANDARDS, AND OPERATOR TECHNIQUES

To verify that the audit equipment, pollutant standards, flowmeters, and operator techniques were correct, NSI-ES performed an audit in the QAD verification lab before and after each audit trip. This comparison was performed for O_3, NO, NO_2, and SO_2. Equipment was handled exactly as in the field: it was unloaded from the vehicle, assembled in the QAD lab, turned on, allowed to warm up, and then used for the verification audit. The same equipment was then transported to the station sites and used to perform the audits. Upon completion of the audits, another verification audit was conducted in the QAD facility.

RESULTS OF QAD AUDIT CERTIFICATION COMPARISONS

Results of the QAD audit verification comparisons conducted before and after each audit trip are summarized in Tables 1 through 4 (O_3, NO, NO_2, and SO_2, respectively). Variable #1 is the QAD analysis of the NSI-ES generated audit concentration. Variable #2 is the NSI-ES calculated value of the generated audit concentration. Variable #3 is the difference (in parts per billion) between Variable #2 and Variable #1. Below the data lists are the "Basic Statistics" for Variable #3.

Following each table is a plot of the estimated line of best fit and its confidence intervals (Figures 5 through 8). The values for slope and intercept are given. These plots are obtained using the "Bartlett Method" computer program authored by M. V. Smith, R. W. Shaw, Jr. and R. J. Paur of the Environmental Sciences Research Laboratory (EPA-ORD-RTP).

These tables and plots summarize the results of four separate certification audits conducted in the QAD facility; they serve as a standard of comparison in evaluating the results of the ORV station audits.

Appendix A presents QAD's official statements of the audit certification comparison results.

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TABLE 1. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR OZONE

```
         Variable # 1   Variable # 2   Variable # 3
OBS#
   1
          0.00000        0.00000        0.00000
   2
         25.00000       28.00000        3.00000
   3
         95.00000      100.00000        5.00000
   4
        126.00000      124.00000       -2.00000
   5
        158.00000      159.00000        1.00000
   6
        201.00000      194.00000       -7.00000
   7
          0.00000        0.00000        0.00000
   8
        185.00000      186.00000        1.00000
   9
        154.00000      154.00000        0.00000
  10
         66.00000       62.00000       -4.00000
  11
         18.00000       19.00000        1.00000
  12
          0.00000        0.00000        0.00000
  13
        179.00000      176.00000       -3.00000
  14
         85.00000       85.00000        0.00000
  15
         34.00000       35.00000        1.00000
  16
         13.00000       13.00000        0.00000
  17
          0.00000        0.00000        0.00000
  18
        181.00000      177.00000       -4.00000
  19
         87.00000       88.00000        1.00000
  20
         35.00000       36.00000        1.00000
  21
         15.00000       14.00000       -1.00000
                                  BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES             SUM              MEAN
DIFF(ppb)                21                0        -7.00000           -.33333
--------------------------------------------------------------------------------
                                                     COEF OF           COEF OF
VARIABLE           VARIANCE   STANDARD DEV.         SKEWNESS          KURTOSIS
DIFF(ppb)           6.63333         2.57553          -.64644            .99335
--------------------------------------------------------------------------------
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN      LOWER LIMIT       UPPER LIMIT
I  F(ppb)         772.65775          .56203         -1.50598            .83932
--------------------------------------------------------------------------------


                                  ORDER STATISTICS


VARIABLE            MAXIMUM         MINIMUM            RANGE          MIDRANGE
DIFF(ppb)           5.00000        -7.00000         12.00000          -1.00000
--------------------------------------------------------------------------------
```

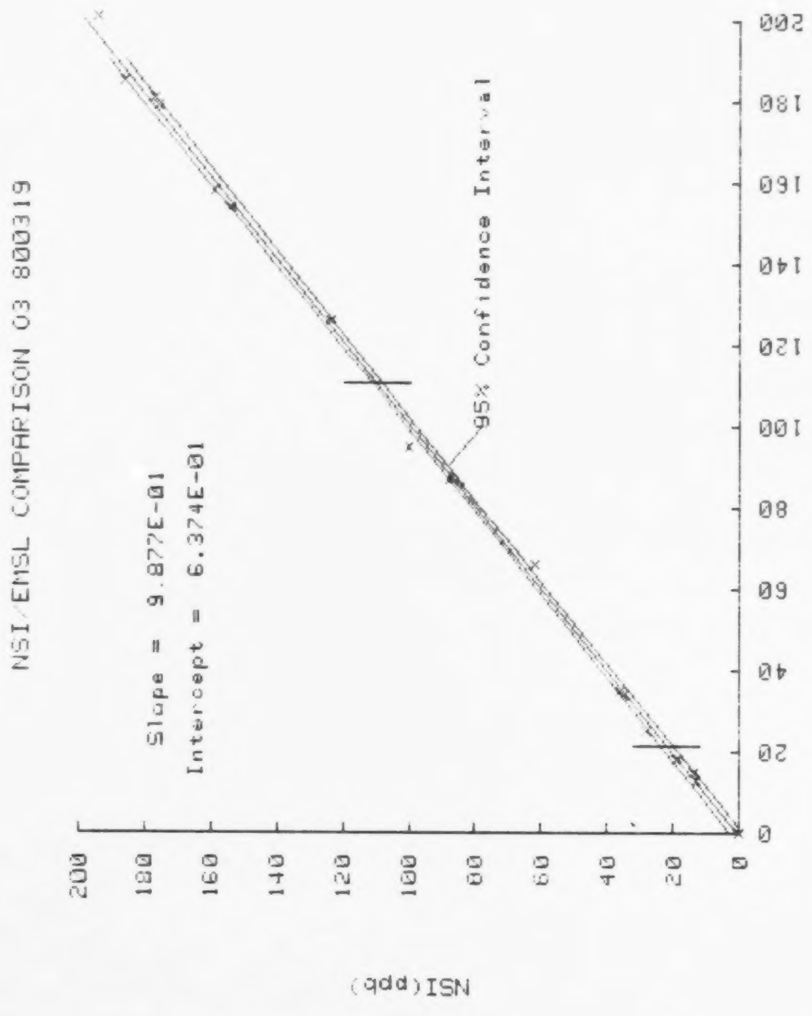

Figure 5. Estimated line of best fit: QAD audit certification comparisons for ozone.

EPA Form 2350-4 (4-80)
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TABLE 2. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR NITRIC OXIDE

OBS#	Variable # 1	Variable # 2	Variable # 3
1	0.00000	0.00000	0.00000
2	85.00000	88.00000	3.00000
3	44.00000	44.00000	0.00000
4	11.00000	11.00000	0.00000
5	6.00000	6.00000	0.00000
6	0.00000	0.00000	0.00000
7	82.00000	84.00000	2.00000
8	63.00000	64.00000	1.00000
9	41.00000	43.00000	2.00000
10	20.00000	21.00000	1.00000
11	10.00000	10.00000	0.00000
12	0.00000	0.00000	0.00000
13	82.00000	85.00000	3.00000
14	47.00000	49.00000	2.00000
15	10.00000	9.90000	-.10000
16	4.50000	4.90000	.40000
17	0.00000	0.00000	0.00000
18	85.00000	89.00000	4.00000
19	52.00000	53.00000	1.00000
20	10.00000	10.00000	0.00000
21	6.00000	6.00000	0.00000

```
                                   BASIC STATISTICS

VARIABLE      # OBSERVATIONS     # MISS. VALUES            SUM             MEAN
DIFF(ppb)                 21                  0       19.30000           .91905
-------------------------------------------------------------------------------
                                                       COEF OF          COEF OF
VARIABLE            VARIANCE     STANDARD DEV.        SKEWNESS         KURTOSIS
DIFF(ppb)            1.57162           1.25364         1.09472          -.02452
-------------------------------------------------------------------------------
                                  STANDARD ERROR  95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN      LOWER LIMIT      UPPER LIMIT
DIFF(ppb)          136.40668            .27357           .34826          1.48984
-------------------------------------------------------------------------------

                                   ORDER STATISTICS


VARIABLE             MAXIMUM           MINIMUM           RANGE         MIDRANGE
DIFF(ppb)            4.00000           -.10000         4.10000          1.95000
----------------------------------
```

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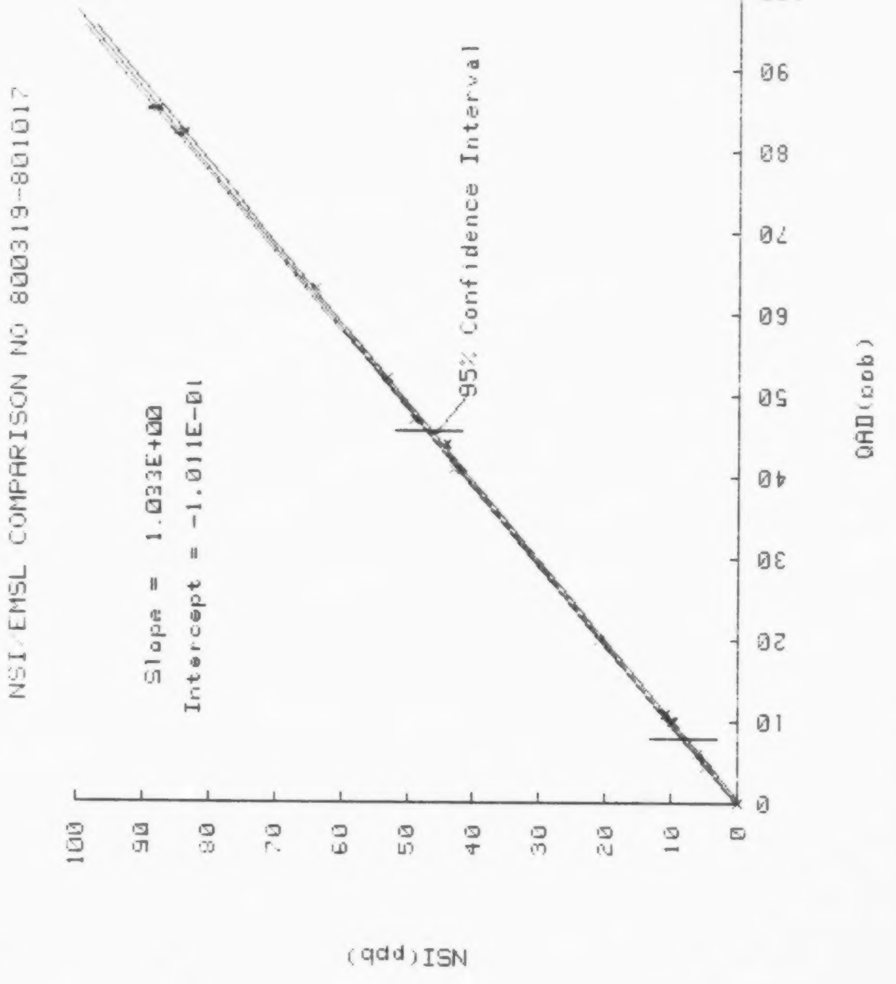

Figure 6. Estimated line of best fit: QAD audit certification comparisons for nitric oxide.

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TABLE 3. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR NITROGEN DIOXIDE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
   1
          0.00000        0.00000        0.00000
   2
         70.00000       71.00000        1.00000
   3
         56.00000       56.00000        0.00000
   4
         37.00000       39.00000        2.00000
   5
         16.00000       14.00000       -2.00000
   6
          0.00000        0.00000        0.00000
   7
         62.00000       66.00000        4.00000
   8
         56.00000       60.00000        4.00000
   9
         36.00000       37.00000        1.00000
  10
         16.00000       19.00000        3.00000
  11
          0.00000        0.00000        0.00000
  12
         72.00000       76.00000        4.00000
  13
         51.00000       53.00000        2.00000
  14
         23.00000       25.00000        2.00000
  15
          7.00000        8.00000        1.00000
  16
          0.00000        0.00000        0.00000
  17
         74.00000       76.00000        2.00000
  18
         53.00000       54.00000        1.00000
  19
         15.00000       17.00000        2.00000
  20
          6.00000        8.00000        2.00000
                         BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES          SUM            MEAN
DIFF(ppb                 20                0     29.00000         1.45000
--------------------------------------------------------------------------
                                                  COEF OF         COEF OF
VARIABLE           VARIANCE   STANDARD DEV.      SKEWNESS        KURTOSIS
DIFF(ppb            2.47105         1.57196       -.03065         -.30432
--------------------------------------------------------------------------
                             STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN   LOWER LIMIT     UPPER LIMIT
DIFF(ppb          108.41091          .35150        .71412         2.18588
--------------------------------------------------------------------------

                         ORDER STATISTICS


VARIABLE            MAXIMUM         MINIMUM         RANGE        MIDRANGE
DIFF(ppb            4.00000        -2.00000       6.00000         1.00000
--------------------------------------------------------------------------
```

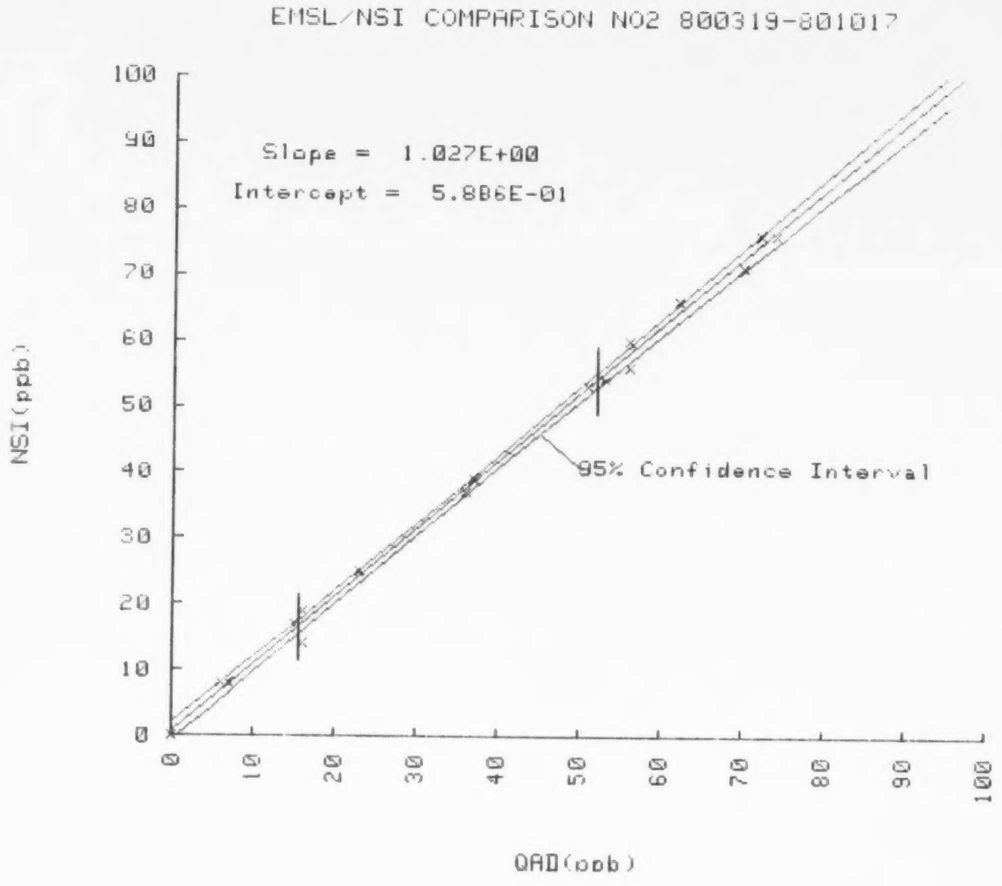

Figure 7. Estimated line of best fit: QAD audit certification comparisons for nitrogen dioxide.

TABLE 4. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR SULFUR DIOXIDE

```
           Variable # 1   Variable # 2   Variable # 3
   OBS#
     1
               0.00000        0.00000        0.00000
     2
              72.30000       76.00000        3.70000
     3
              38.00000       37.80000        -.20000
     4
              14.00000       16.30000        2.30000
     5
               2.00000        4.00000        2.00000
     6
               0.00000        0.00000        0.00000
     7
              79.00000       80.00000        1.00000
     8
              63.00000       64.00000        1.00000
     9
              32.00000       32.00000        0.00000
    10
              15.00000       16.00000        1.00000
    11
               0.00000        0.00000        0.00000
    12
              79.30000       80.00000         .70000
    13
              45.50000       45.80000         .30000
    14
               9.00000        9.10000         .10000
    15
               5.10000        5.00000        -.10000
    16
               0.00000        0.00000        0.00000
    17
              85.00000       89.00000        4.00000
    18
              39.00000       40.80000        1.80000
    19
               6.50000        8.00000        1.50000
    20
               4.00000        5.30000        1.30000
                                   BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES            SUM            MEAN
DIFF(ppb)                 20                0       20.40000         1.02000
-----------------------------------------------------------------------------
                                                     COEF OF         COEF OF
VARIABLE            VARIANCE    STANDARD DEV.       SKEWNESS        KURTOSIS
DIFF(ppb)            1.52589          1.23527        1.13580          .44259
-----------------------------------------------------------------------------
                                STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIFF(ppb)          121.10501           .27622          .44173         1.59827
-----------------------------------------------------------------------------

                                   ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM          RANGE        MIDRANGE
DIFF(ppb)            4.00000          -.20000        4.20000         1.90000
-----------------------------------------------------------------------------
```

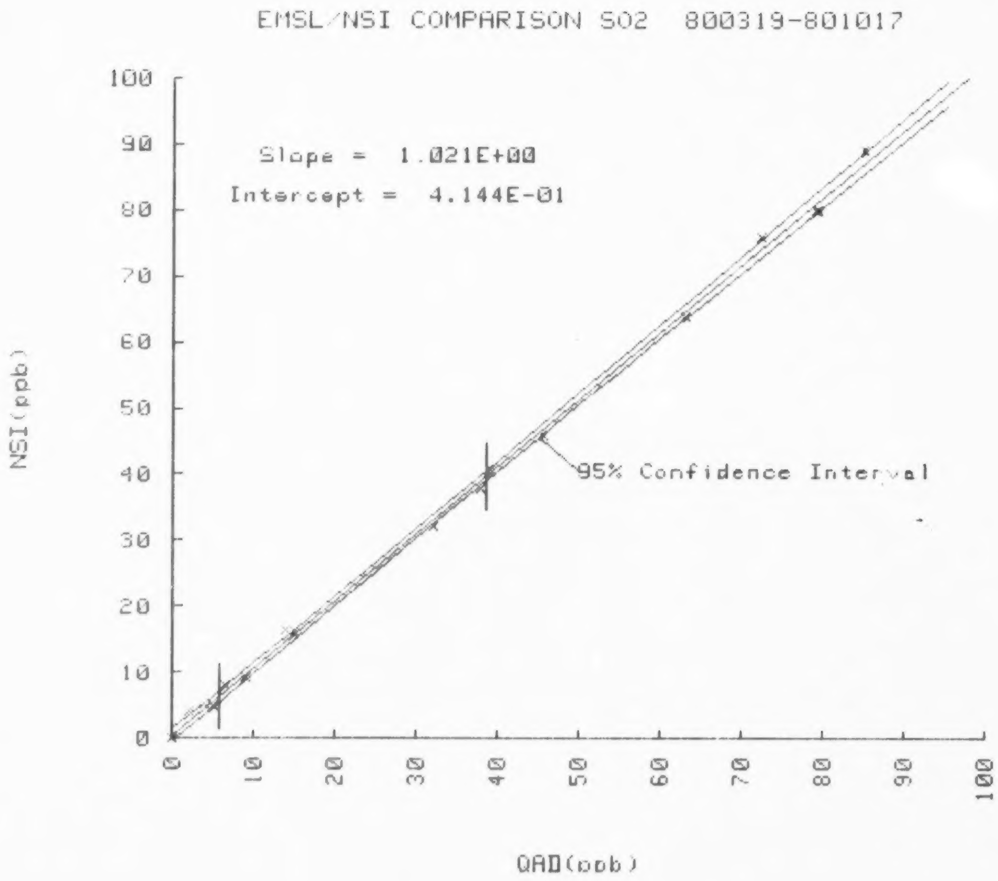

Figure 8. Estimated line of best fit: QAD audit certification comparisons for sulfur dioxide.

SECTION 5

CRITERIA OF ACCEPTABLE PERFORMANCE

The criteria for acceptable performance presented below are offered as a basis for discussion and not as a judgment of the validity of the data collected by MTL.

CONTINUOUS ANALYZERS

Criteria for the gaseous analyzers were based on the QAD audit certification comparisons conducted before and after each audit. The standard deviation of the difference (expressed in parts per billion) calculated for each NSI-ES/QAD comparison was used as a standard.

Similarly for the NSI-ES/MTL comparisons, the standard deviation of the difference (expressed in parts per billion) was calculated for each analyzer for each audit. A grade was determined using the equation

$$\text{grade} = 100 - 10\left(\frac{\text{MTL} - \text{NSI}}{\text{NSI}}\right)$$

where NSI = standard deviation of the difference (ppb) in the NSI-ES/QAD comparison

MTL = standard deviation of the difference (ppb) in the NSI-ES/MTL comparison

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Thus, if an NSI-ES/MTL comparison yields a standard deviation that is 3 times the standard deviation of the corresponding NSI-ES/QAD comparison, the grade is 80. A grade of <70 indicates unacceptable performance.

PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

For the particulate samplers and meteorological sensors, station grades were determined using an equation that is based on the percent difference only, since the measurements involved were (for the most part) single point measurements and because comparison audits to evaluate operator technique and calibration standards were not performed. The devices used to audit these sensors are however, calibrated periodically.

Station grades were calculated by the equation:

$$\text{grade} = 100 - 20\left(\left|\frac{\text{MTL-NSI}}{\text{NSI}}\right|\right)$$

where MTL = value indicated by sensor

NSI = value indicated by audit device

Thus a sensor which differed by 10% would receive a grade of 80. A difference of >15% yields of grade of <70, indicating unacceptable performance.

The nephelometer has zero check points, and percent difference was expressed as percent of full scale. For instruments having several auditable check points, the absolute values of the percent differences were summed and averaged, and the mean absolute percent difference used to determine grade.

SECTION 6

SUMMARY OF AUDIT RESULTS

Appendix B presents the individual results of the first 3 audits.

CONTINUOUS ANALYZERS

Tables 5 through 16 summarize the results of the 3 audits of gaseous analyzers. Data are listed in the chronological order in which they were obtained. Variable #1 is the NSI-ES audit concentration; Variable #2 is the MTL analyzer response; and Variable #3 the difference (in parts per billion) between Variable #2 and Variable #1. Below each data list are the "Basic Statistics" for Variable #3.

Following each table is a plot of the estimated line of best fit and its confidence intervals (Figures 9 through 20). These plots were obtained in the same manner as those presented in Section 4.

The standard deviations given in the "Basic Statistics" were used to calculate a grade for each pollutant at each station (see Section 5 for method). Table 17 displays these grades.

PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

The results of the particulate and meteorological sampling system audits are summarized in Table 18. The results of the first high volume sampler audit were determined to be invalid and are not included. Grades were calculated as described in Section 5 and are offered here for purposes of discussion and not as a measure of the validity of data collected by the ORV stations.

PROBLEMS ENCOUNTERED DURING AUDITS

Certain problems arose during conduct of the first three audits. One is that station operators conducting calibration checks after the audits sometimes obtained different results. In future audits, calibration checks will be performed by the station operators while NSI-ES personnel are onsite; any discrepancies will be resolved immediately.

During the third audit (September 1980), the zero point audit of the Columbia Scientific oxides of nitrogen analyzer was found to yield high (~5 ppb) values before the audit and values closer to zero at the end of the audit. This problem may be responsible for upscale indication of the zero air audit point in earlier audits, and will be be explored further in the next audit (November).

The Meloy sulfur analyzer is very sensitive to humidity changes. The station operators and NSI-ES audit personnel attempted to generate identical humidity levels; however, the procedures and equipment employed for this purpose may be inadequate. During the upcoming November audit, an EGG dew point hygrometer will be used to compare humidity levels generated by the station operators to those generated by the NSI-ES audit team.

Questions arose concerning the dew point measurements; current efforts are aimed at identifying a better instrument.

TABLE 5. SUMMARY: AUDIT OF MORGANFIELD STATION FOR OZONE

```
          Variable # 1   Variable # 2   Variable # 3
 OBS#
    1
            0.00000        1.04190        1.04190
    2
           19.00000       22.96590        3.96590
    3
           40.00000       42.80190        2.80190
    4
          114.00000      135.71800       21.71800
    5
          168.00000      194.18200       26.18200
    6
            0.00000        -.48865        -.48865
    7
          163.00000      164.38200        1.38200
    8
          125.00000      125.01000         .01000
    9
           43.00000       46.26560       -1.73440
   10
            9.00000        9.45278         .45278
   11
          153.00000      151.19200       -1.80800
   12
           63.00000       63.55790         .55790
   13
           24.00000       23.18510        -.81490
   14
           12.00000       14.00000        2.00000
   15
            0.00000        -.92370        -.92370

                                  BASIC STATISTICS

VARIABLE       # OBSERVATIONS   # MISS. VALUES
DIFF(ppb)                  15                0           SUM            MEAN
                                                   54.34353         3.62290
-----------------------------------------------------------------------------
                                                    COEF OF         COEF OF
VARIABLE             VARIANCE   STANDARD DEV.      SKEWNESS        KURTOSIS
DIFF(ppb)            71.38675         8.44907       2.04708         2.54803
-----------------------------------------------------------------------------
                               STANDARD ERROR  95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE       COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIFF(ppb)           233.21271         2.18154      -1.05721         8.30302
-----------------------------------------------------------------------------

                                  ORDER STATISTICS


VARIABLE
DIFF(ppb)             MAXIMUM         MINIMUM          RANGE       MIDRANGE
                     26.18200        -1.80800       27.99000       12.18700
-----------------------------------------------------------------------------
```

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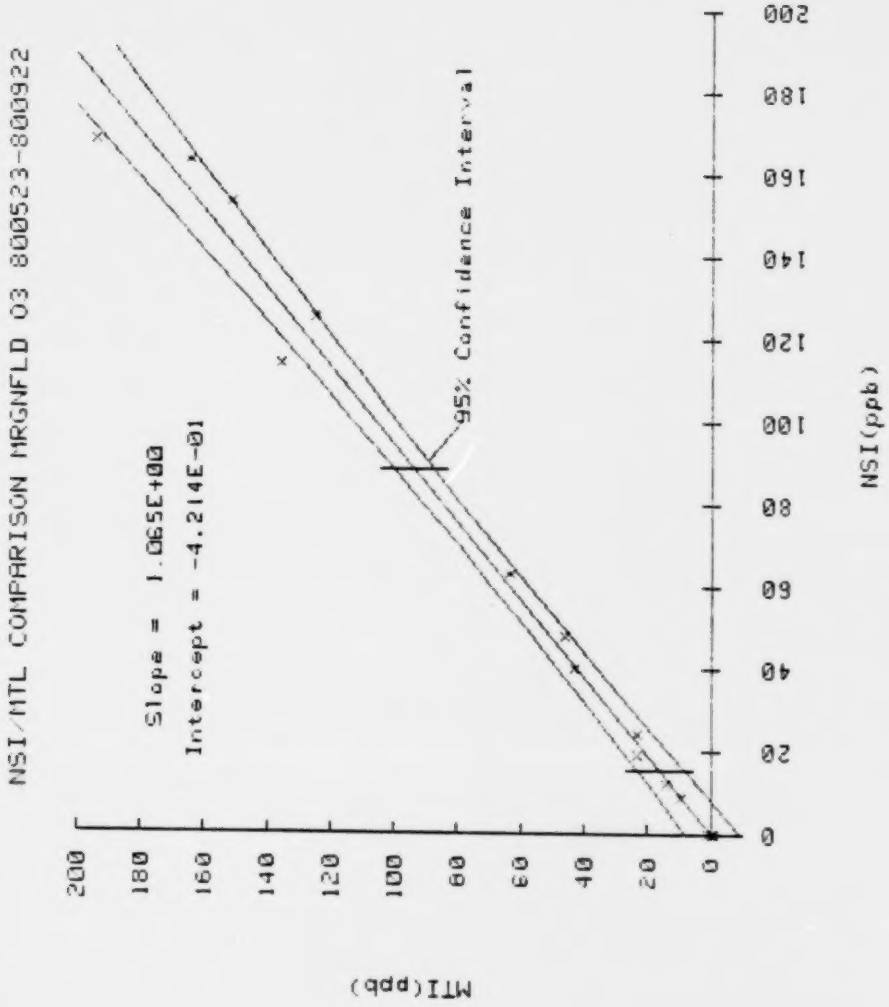

Figure 9. Estimated line of best fit: Audit of Morganfield station for ozone.

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TABLE 6. SUMMARY: AUDIT OF MORGANFIELD STATION FOR NITRIC OXIDE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
  1
          0.00000        1.00100        1.00100
  2
         88.00000      101.15100       13.15100
  3
         44.00000       51.17620        7.17620
  4
         11.20000       12.21780        1.01780
  5
          6.00000        6.00850         .00850
  6
          0.00000        2.38766        2.38766
  7
         84.00000       83.07410        -.92590
  8
         43.00000       43.47700         .47700
  9
         93.00000       91.82440       -1.17560
 10
         52.00000       51.84470        -.15530
 11
         10.60000       11.46620         .86620
 12
          5.40000        6.18210         .78210
 13
          0.00000        1.99470        1.99470

                         BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES
DIFF(ppb)                13                0        SUM            MEAN
                                                 26.60536        2.04657
-------------------------------------------------------------------------
                                                  COEF OF         COEF OF
VARIABLE           VARIANCE   STANDARD DEV.       SKEWNESS        KURTOSIS
DIFF(ppb)          15.46390         3.93243       2.01920         3.09197
-------------------------------------------------------------------------
                              STANDARD ERROR  95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIFF(ppb)         192.14753         1.09066        -.33039         4.42352
-------------------------------------------------------------------------

                         ORDER STATISTICS

VARIABLE          MAXIMUM        MINIMUM          RANGE         MIDRANGE



DIFF(ppb)        13.15100       -1.17560       14.32660          5.98770
-------------------------------------------------------------------------
```

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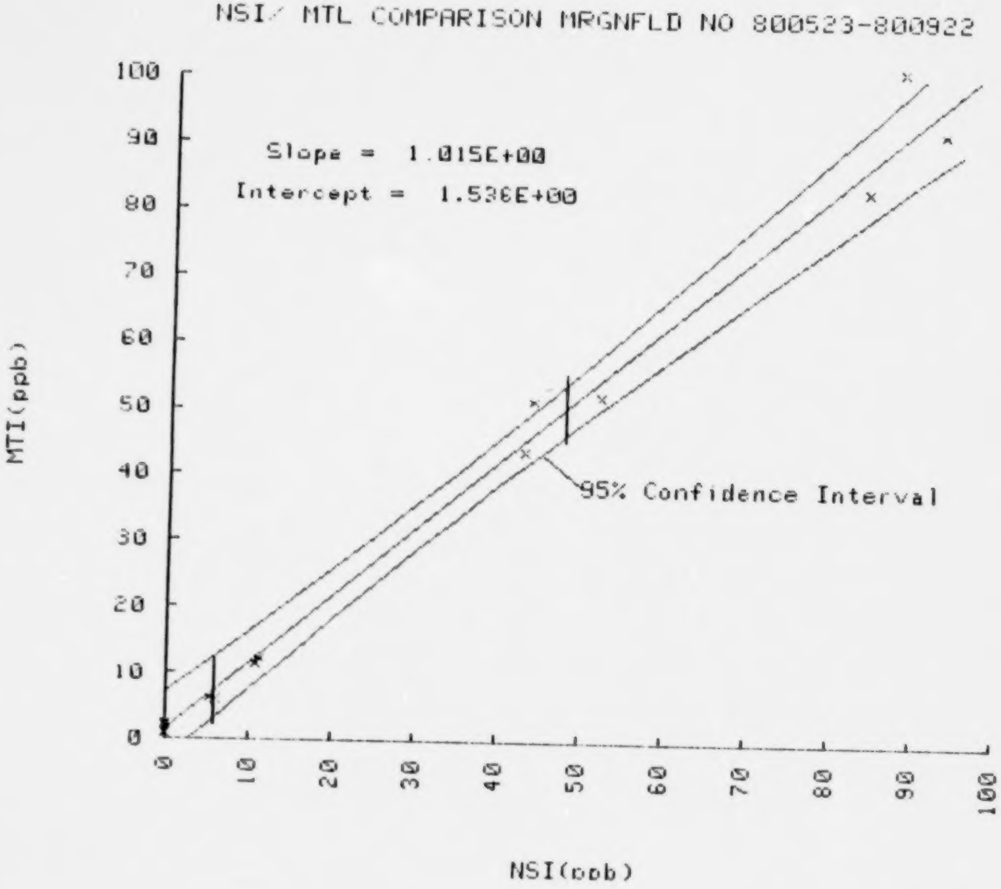

Figure 10. Estimated line of best fit: Audit of Morganfield station for nitric oxide.

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TABLE 7. SUMMARY: AUDIT OF MORGANFIELD STATION FOR NITROGEN DIOXIDE

```
      Variable # 1   Variable # 2   Variable # 3
OBS#
  1      0.00000        1.05350        1.05350
  2     72.00000       80.99220        8.99220
  3     59.00000       64.32950        5.32950
  4     38.00000       37.96450        -.03550
  5     14.00000        9.49030       -4.50970
  6     13.00000        7.38110       -5.61890
  7      0.00000        3.80381        3.80381
  8     80.30000       72.28860       -8.01140
  9     60.30000       54.91030       -5.38970
 10     53.30000       48.22640       -5.07360
 11     21.80000       18.81700       -2.98300
 12     83.80000       72.14700      -11.65300
 13     44.30000       59.91130       15.61130
 14     21.10000       13.39470       -7.70530
 15      9.40000        1.68638       -7.71362
 16      0.00000        4.95626        4.95626

                             BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES             SUM            MEAN
DIFF(ppb)                 16                0       -18.94715        -1.18420
-------------------------------------------------------------------------------
                                                      COEF OF         COEF OF
VARIABLE            VARIANCE   STANDARD DEV.         SKEWNESS        KURTOSIS
DIFF(ppb)           53.67519         7.32634           .72700         -.20995
-------------------------------------------------------------------------------


                               STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION      OF THE MEAN      LOWER LIMIT      UPPER LIMIT
DIFF(ppb)         618.67547          1.83158       -5.08910          2.72071
-------------------------------------------------------------------------------

                             ORDER STATISTICS

VARIABLE             MAXIMUM         MINIMUM
DIFF(ppb)           15.61130       -11.65300           RANGE        MIDRANGE
                                                    27.26430         1.97915
-------------------------------------------------------------------------------
```

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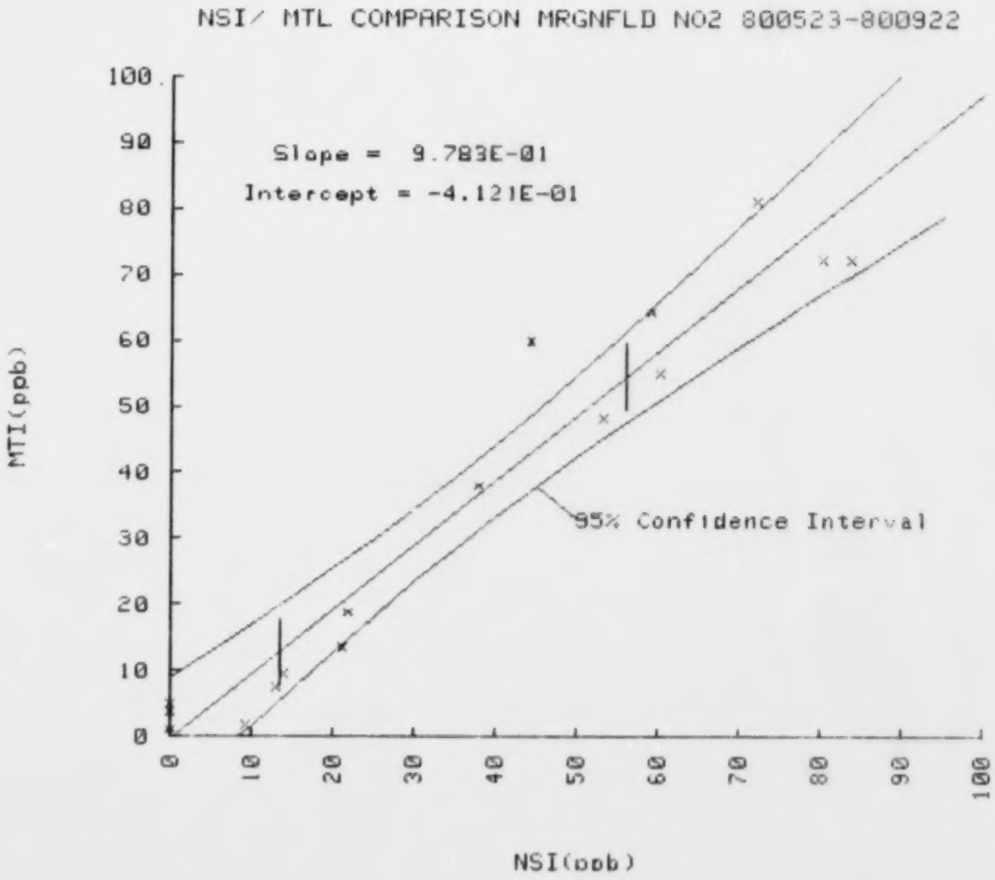

Figure 11. Estimated line of best fit: Audit of Morganfield station for nitrogen dioxide.

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TABLE 8. SUMMARY: AUDIT OF MORGANFIELD STATION FOR SULFUR DIOXIDE

```
       Variable # 1   Variable # 2   Variable # 3
 OBS#
    1
          0.00000       -2.31100       -2.31100
    2
         80.00000       95.67260       15.67260
    3
         64.00000       74.64720       10.64720
    4
         32.30000       33.20000         .90000
    5
         16.20000       14.18660       -2.01340
    6
         91.00000       97.07900        6.07900
    7
         52.70000       49.89020       -2.80980
    8
         12.30000       10.80880       -1.49120
    9
          5.60000        4.36448       -1.23552
   10
          0.00000        3.42902        3.42902
                                 BASIC STATISTICS

VARIABLE      # OBSERVATIONS    # MISS. VALUES             SUM              MEAN
DIFF(ppb)                 10                 0        26.86610           2.68661
-------------------------------------------------------------------------------------
                                                       COEF OF           COEF OF
VARIABLE            VARIANCE    STANDARD DEV.         SKEWNESS          KURTOSIS
DIFF(ppb)           39.70892          6.30150          1.02979           -.24688
-------------------------------------------------------------------------------------
                                STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN      LOWER LIMIT       UPPER LIMIT
DIFF(ppb)          234.55215          1.99271         -1.82241           7.19563
-------------------------------------------------------------------------------------


                                 ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM            RANGE          MIDRANGE
DIFF(ppb)           15.67260         -2.80980         18.48240           6.43140
```

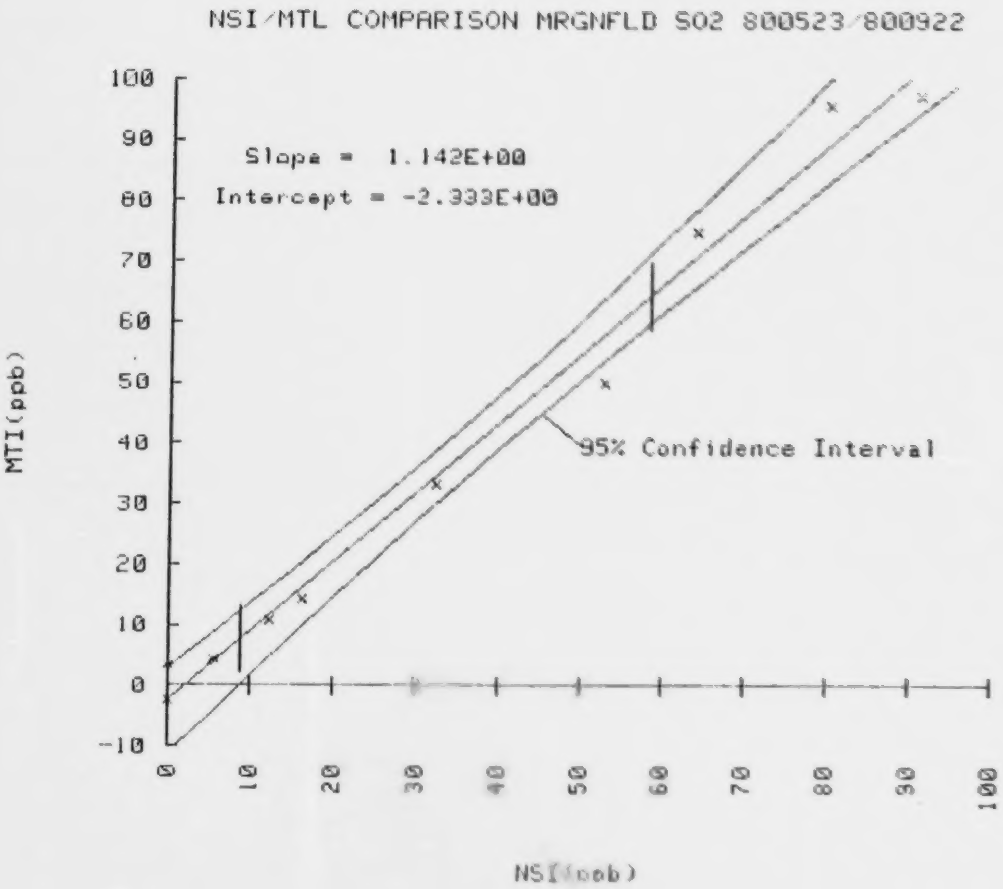

Figure 12. Estimated line of best fit: Audit of Morganfield station for sulfur dioxide.

TABLE 9. SUMMARY: AUDIT OF BROOKVILLE STATION FOR OZONE

```
       Variable # 1   Variable # 2   Variable # 3
OBS#
  1
          0.00000        2.00000        2.00000
  2
        181.00000      191.00000       10.00000
  3
        135.00000      136.00000        1.00000
  4
         49.00000       48.20000        -.80000
  5
         17.00000       17.00000        0.00000
  6
          0.00000        -.00200         .00200
  7
        173.00000      184.97400      -11.97400
  8
        105.00000      117.25100      -12.25100
  9
         49.00000       56.60200       -7.60200
 10
         12.00000        8.08440        3.91560
 11
        158.00000      156.45100       -1.54900
 12
         66.00000       68.19620        2.19620
 13
         69.00000       40.71670      -28.28330
 14
         18.00000       20.65870        2.65870
 15
          5.00000        7.01930        2.01930
 16
          0.00000        1.00190        1.00190
                                    BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES             SUM            MEAN
DIFF(ppb)                16                0       -37.66640        -2.35415
------------------------------------------------------------------------------
                                                     COEF OF         COEF OF
VARIABLE           VARIANCE    STANDARD DEV.        SKEWNESS        KURTOSIS
DIFF(ppb)          80.19224          8.95501        -1.61198         2.50549
------------------------------------------------------------------------------
                               STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION       OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIFF(ppb)         380.39259          2.23875        -7.12713         2.41883
------------------------------------------------------------------------------
                                    ORDER STATISTICS


VARIABLE            MAXIMUM          MINIMUM           RANGE        MIDRANGE
DIFF(ppb)          10.00000        -28.28330        38.28330        -9.14165
------------------------------------------------------------------------------
```

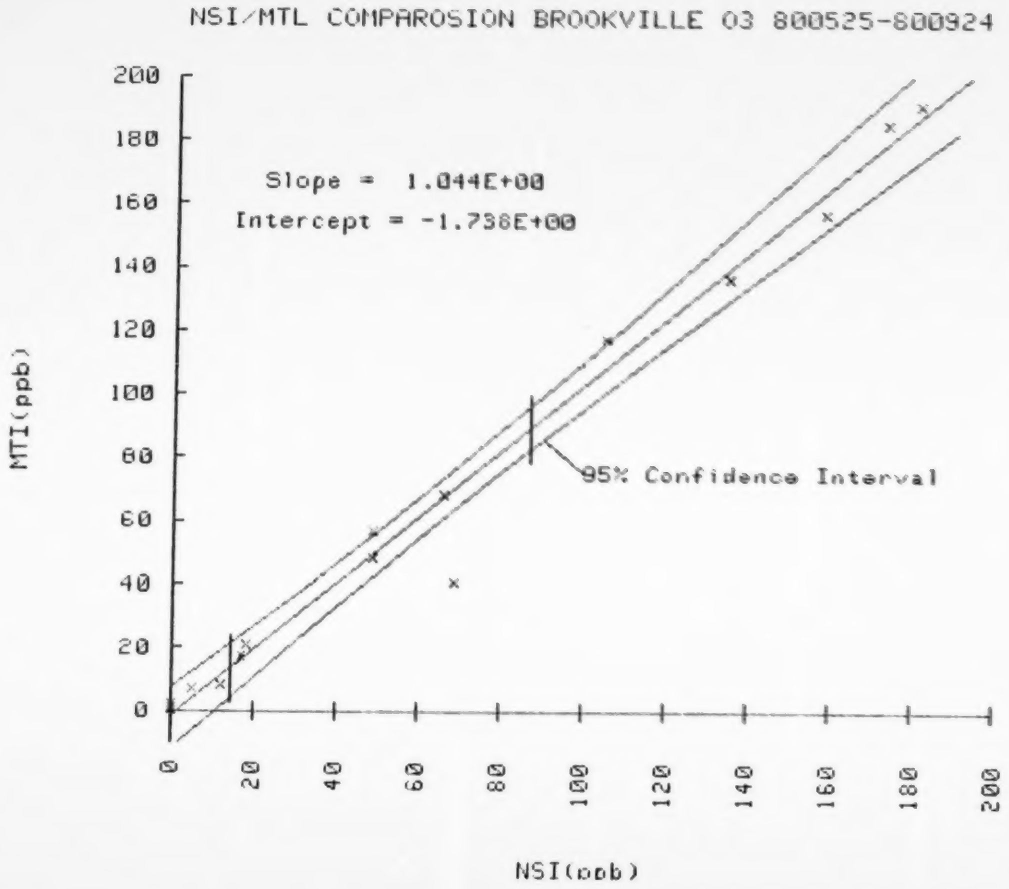

Figure 13. Estimated line of best fit: Audit of Brookville station for ozone.

TABLE 10. SUMMARY: AUDIT OF BROOKVILLE STATION FOR NITRIC OXIDE

```
         Variable # 1   Variable # 2   Variable # 3
OBS#
   1
          0.00000         .19882         .19882
   2
         84.00000       80.68040       -3.31960
   3
         64.00000       61.60330       -2.39670
   4
         43.00000       40.93640       -2.06360
   5
         21.00000       20.36890        -.63110
   6
         10.00000       10.23420         .23420
   7
         84.00000       82.61440       -1.38560
   8
         52.00000       52.08720         .08720
   9
         10.30000       11.18270         .88270
  10
          6.40000        7.35415         .95415
  11
          0.00000        1.91365        1.91365

                                BASIC STATISTICS



VARIABLE     # OBSERVATIONS   # MISS. VALUES             SUM             MEAN
DIFF(ppb)                11                0        -5.52588          -.50235
------------------------------------------------------------------------------
                                                     COEF OF          COEF OF
VARIABLE           VARIANCE   STANDARD DEV.         SKEWNESS         KURTOSIS
DIFF(ppb)           2.60182         1.61302          -.32129          -.96345
------------------------------------------------------------------------------
                              STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION      OF THE MEAN      LOWER LIMIT      UPPER LIMIT
DIFF(ppb)         321.09224          .48634         -1.58628           .58157
------------------------------------------------------------------------------

                                ORDER STATISTICS


VARIABLE            MAXIMUM         MINIMUM            RANGE         MIDRANGE
DIFF(ppb)           1.91365        -3.31960          5.23325          -.70298
------------------------------------------------------------------------------
```

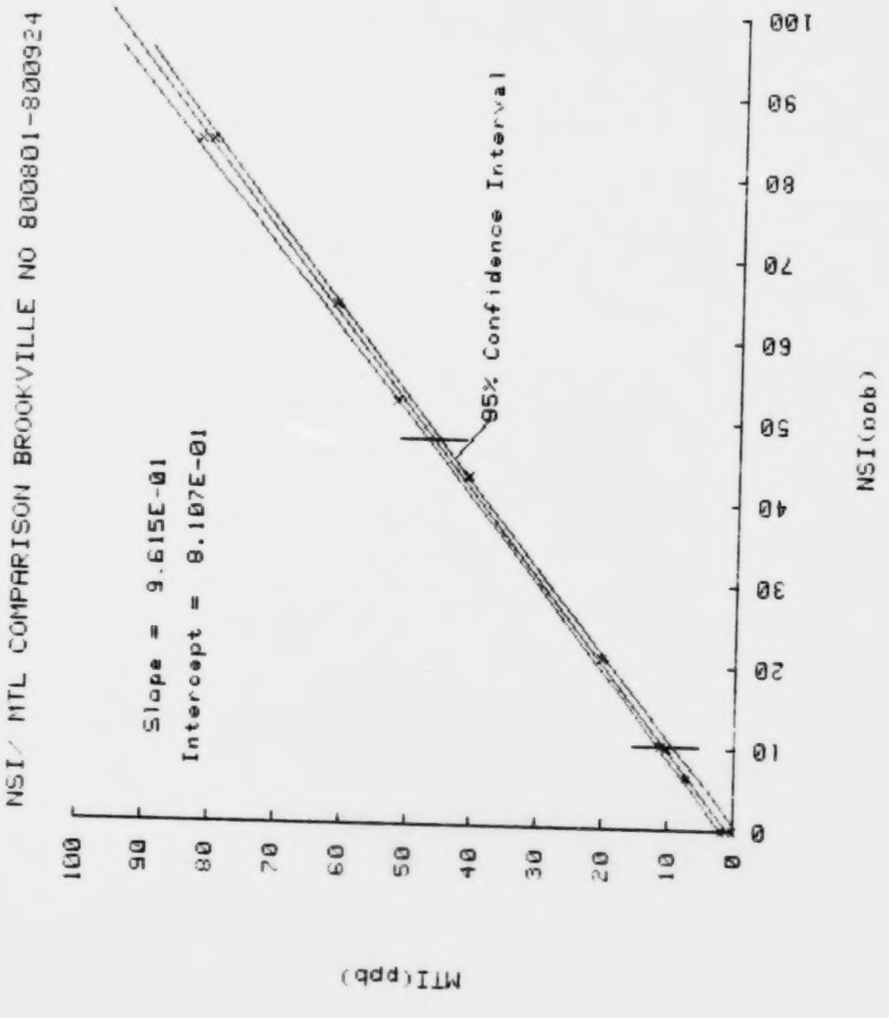

Figure 14. Estimated line of best fit: Audit of Brookville station for nitric oxide.

TABLE 11. SUMMARY: AUDIT OF BROOKVILLE STATION FOR NITROGEN DIOXIDE

```
      Variable # 1   Variable # 2   Variable # 3
OBS#
  1
         0.00000        1.69503        1.69503
  2
        66.40000       65.99510        -.40490
  3
        39.36000       41.57100        2.27100
  4
        17.20000       18.24360        1.04360
  5
         4.90000        9.07209        4.17209
  6
        68.40000       64.97060       -3.42940
  7
        62.00000       56.40850       -5.59150
  8
        18.40000       16.92230       -1.47770
  9
         5.80000        5.43912        -.36088
 10
         0.00000        1.40992        1.40992

                                   BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES              SUM             MEAN
DIFF(ppb)                 10                0           -.67274           -.06727
---------------------------------------------------------------------------------
                                                       COEF OF          COEF OF
VARIABLE            VARIANCE   STANDARD DEV.          SKEWNESS         KURTOSIS
DIFF(ppb)            8.21912         2.86690           -.54882          -.38321
---------------------------------------------------------------------------------
                                STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN       LOWER LIMIT      UPPER LIMIT
DIFF(ppb)         4261.52783            .90659          -2.11868          1.98413
---------------------------------------------------------------------------------



                                   ORDER STATISTICS


VARIABLE             MAXIMUM         MINIMUM             RANGE         MIDRANGE
DIFF(ppb)            4.17209        -5.59150           9.76359          -.70971
---------------------------------------------------------------------------------
```

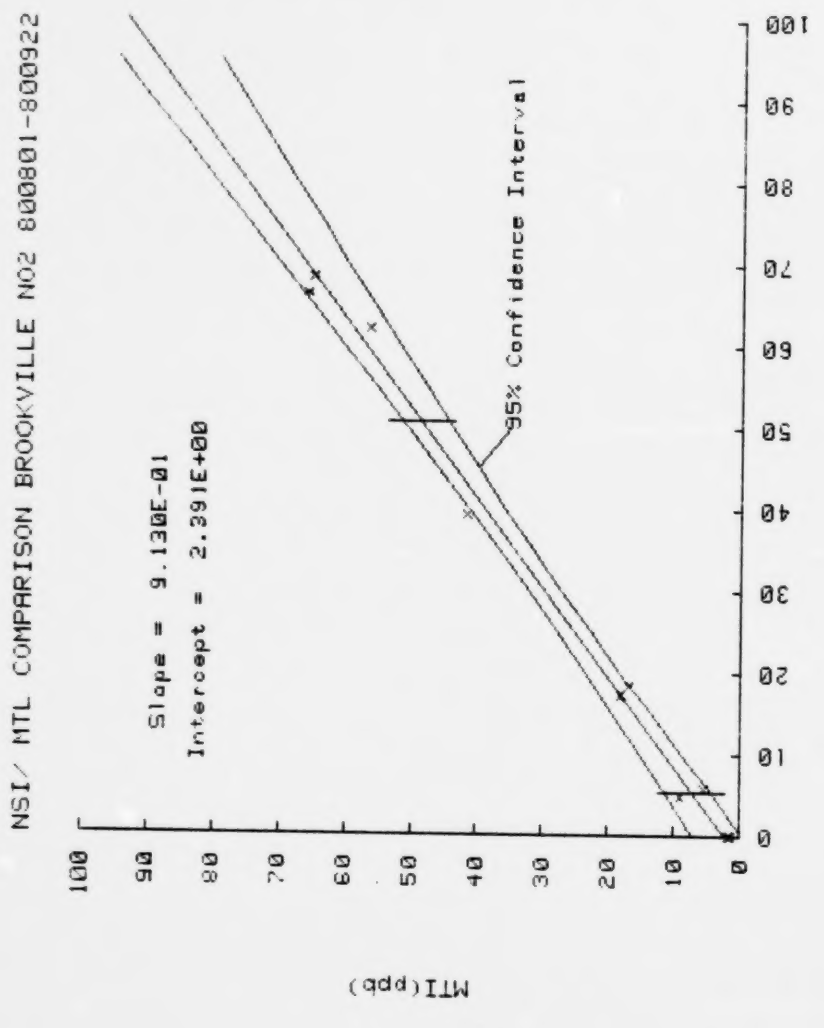

Figure 15. Estimated line of best fit: Audit of Brookville station for nitrogen dioxide.

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TABLE 12. SUMMARY: AUDIT OF BROOKVILLE STATION FOR SULFUR DIOXIDE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
  1
            0.00000       -6.65170       -6.65170
  2
           80.00000       77.45540       -2.54460
  3
           64.00000       61.56740       -2.43260
  4
           32.30000       26.81240       -5.48760
  5
           16.20000        4.96640      -11.23360
  6
           88.80000       87.88930        -.91070
  7
           40.80000       40.39060        -.40940

                               BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES          SUM            MEAN
DIFF(ppb)                 7                0    -29.67020        -4.23860
-------------------------------------------------------------------------
                                                  COEF OF         COEF OF
VARIABLE           VARIANCE   STANDARD DEV.      SKEWNESS        KURTOSIS



DIFF(ppb)          14.69701         3.83367       -.81318         -.49114
-------------------------------------------------------------------------
                             STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIFF(ppb)          90.44655         1.44899      -7.78507         -.69213
-------------------------------------------------------------------------

                               ORDER STATISTICS

VARIABLE            MAXIMUM         MINIMUM         RANGE        MIDRANGE
DIFF(ppb)           -.40940       -11.23360      10.82420        -5.82150
-------------------------------------------------------------------------
```

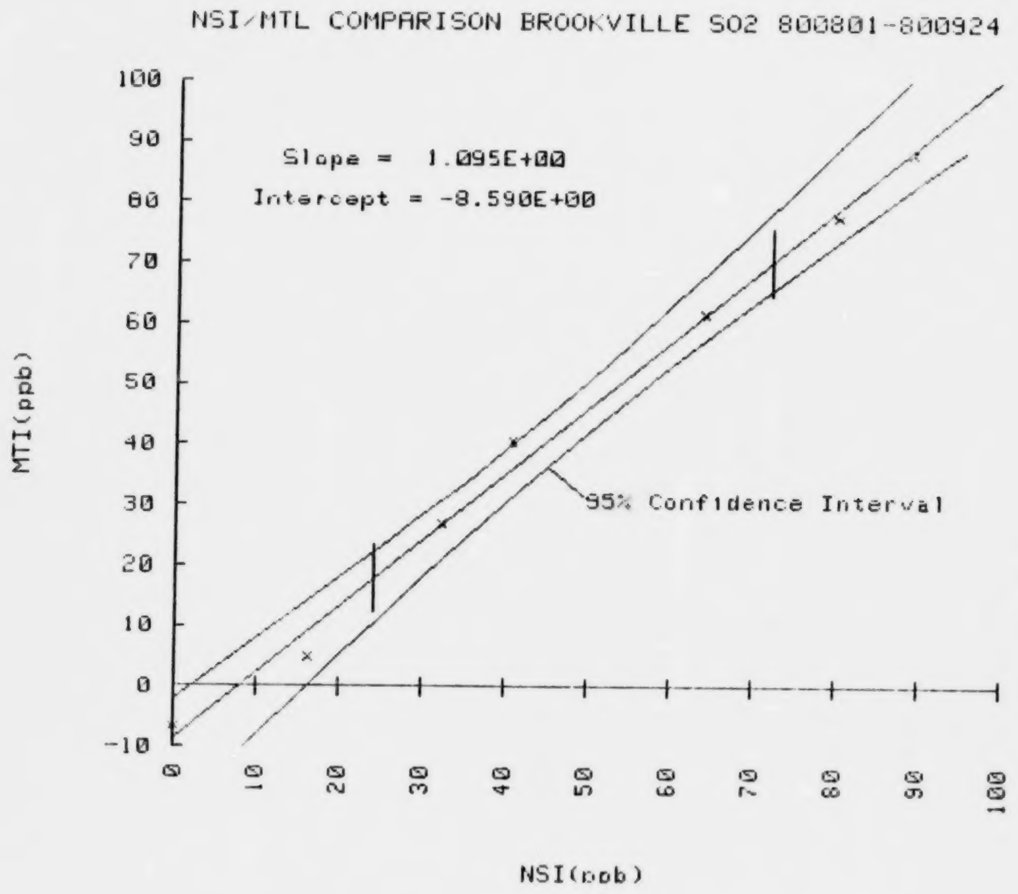

Figure 16. Estimated line of best fit: Audit of Brookville station for sulfur dioxide.

TABLE 13. SUMMARY: AUDIT OF PERRYSVILLE STATION FOR OZONE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
  1
         0.00000         -.97910        -.97910
  2
       181.00000       184.46800        3.46800
  3
       143.00000       142.27600        -.72400
  4
        62.00000        58.48160       -3.51840
  5
        14.00000        12.16900       -1.83100
  6
         0.00000          .29984          .29984
  7
       145.00000       175.48900       30.48900
  8
       108.00000       126.35200       18.35200
  9
        44.00000        49.53730        5.53730
 10
        13.40000         5.31384       -8.08616
 11
       180.00000       161.62700      -18.37300
 12
        76.00000        65.84780      -10.15220
 13
        45.00000        38.90990       -6.09010
 14
        21.00000        18.15770       -2.84230
 15
         7.00000         6.98350        -.01650
 16
         0.00000          .39868          .39868

                              BASIC STATISTICS

VARIABLE      # OBSERVATIONS    # MISS. VALUES            SUM             MEAN
DIFF(ppb)                 16                 0        5.93206           .37075
--------------------------------------------------------------------------------
                                                      COEF OF          COEF OF
VARIABLE            VARIANCE    STANDARD DEV.        SKEWNESS         KURTOSIS
DIFF(ppb)          125.03442         11.18188         1.21002          1.87203
--------------------------------------------------------------------------------
                                STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN     LOWER LIMIT       UPPER LIMIT
DIFF(ppb)         3015.98544          2.79547        -5.58914          6.33064
--------------------------------------------------------------------------------


                              ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM           RANGE         MIDRANGE
DIFF(ppb)           30.48900        -18.37300        48.86200          6.05800
--------------------------------------------------------------------------------
```

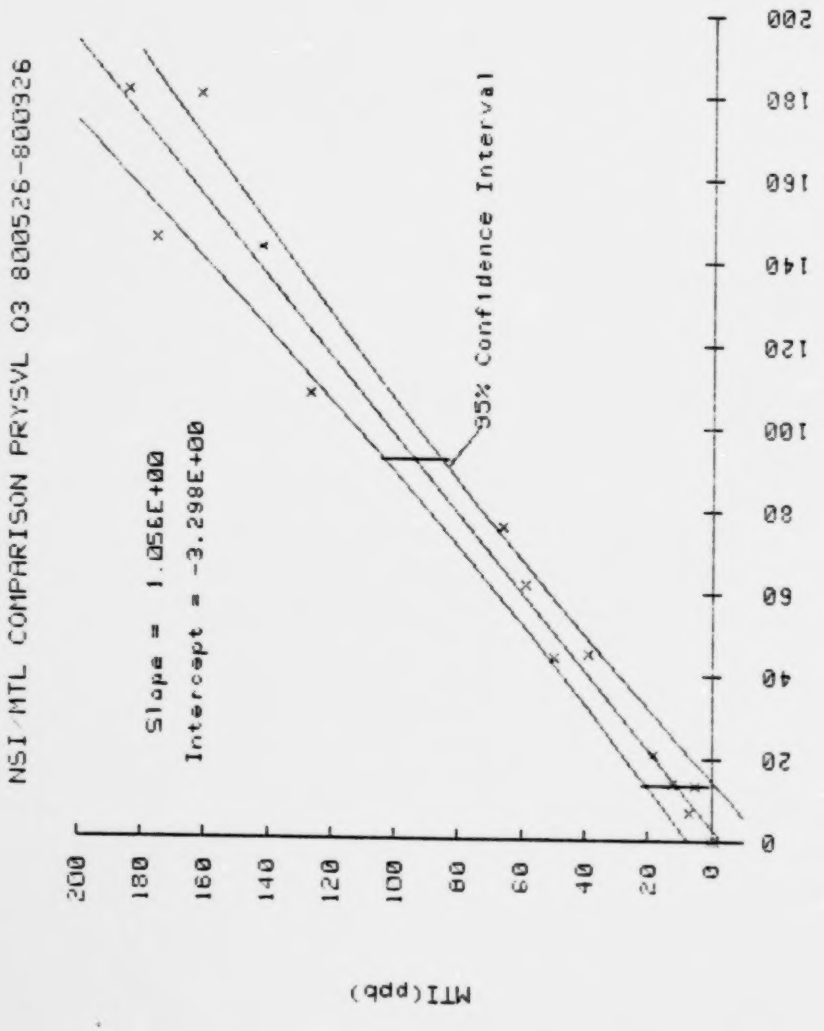

Figure 17. Estimated line of best fit: Audit of Perrysville station for ozone.

TABLE 14. SUMMARY: AUDIT OF PERRYSVILLE STATION FOR NITRIC OXIDE

```
         Variable # 1   Variable # 2   Variable # 3
OBS#
  1
          0.00000       -1.70618       -1.70618
  2
         88.00000       88.38850         .38850
  3
         44.00000       44.19490         .19490
  4
         11.20000        8.53870       -2.66130
  5
          6.00000        2.41186       -3.58814
  6
          0.00000         .29464         .29464
  7
         84.00000       96.40730       12.40730
  8
         43.00000       51.46390        8.46390
  9
         88.00000       88.14140         .14140
 10
         55.00000       55.74680         .74680
 11
         11.00000       12.52080        1.52080
 12
          6.80000       10.43410        3.63410
 13
          0.00000        2.48445        2.48445

                          BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES          SUM          MEAN
DIFF(ppb)                 13                0     22.32117       1.71701
-------------------------------------------------------------------------
                                                   COEF OF       COEF OF



VARIABLE            VARIANCE    STANDARD DEV.     SKEWNESS      KURTOSIS
DIFF(ppb)           19.38889          4.40328      1.26931        .95350
-------------------------------------------------------------------------
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION     OF THE MEAN    LOWER LIMIT   UPPER LIMIT
DIFF(ppb)          256.45012         1.22125        -.94455       4.37857
-------------------------------------------------------------------------

                          ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM        RANGE      MIDRANGE
DIFF(ppb)           12.40730         -3.58814     15.99544       4.40958
-------------------------------------------------------------------------
```

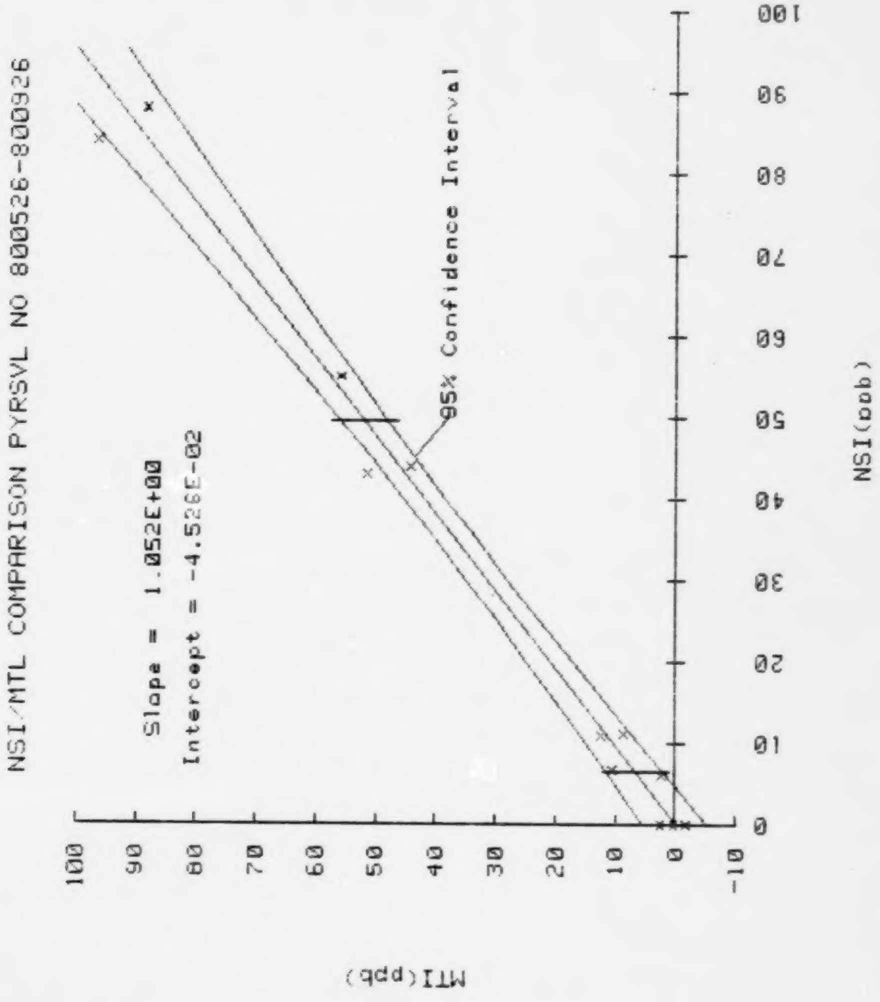

Figure 18. Estimated line of best fit: Audit of Perrysville station for nitric oxide.

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TABLE 15. SUMMARY: AUDIT OF PERRYSVILLE STATION FOR NITROGEN DIOXIDE

```
         Variable # 1   Variable # 2   Variable # 3
OBS#
   1
           0.00000        5.21150        5.21150
   2
          71.00000       74.01650        3.01650
   3
          64.00000       67.03100        3.03100
   4
          39.00000       41.07350        2.07350
   5
          21.00000       20.32780        -.67220
   6
          10.00000        8.33900       -1.66100
   7
           0.00000        3.28482        3.28482
   8
          73.60000       79.73150        6.13150
   9
          79.70000       77.18210       -2.51790
  10
          62.30000       60.88460       -1.41540
  11
          16.60000       16.19460        -.40540
  12
           5.50000        5.32960        -.17040
  13
           0.00000        1.22960        1.22960

                           BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES            SUM              MEAN
DIFF(ppb)                 13                0       17.13692           1.31822
-----------------------------------------------------------------------------------
                                                     COEF OF            COEF OF
VARIABLE            VARIANCE    STANDARD DEV.       SKEWNESS           KURTOSIS
DIFF(ppb)            7.40037          2.72036         .29669           -1.05595
-----------------------------------------------------------------------------------
                               STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION      OF THE MEAN      LOWER LIMIT        UPPER LIMIT
DIFF(ppb)          206.36566           .75449         -.32610            2.96255
-----------------------------------------------------------------------------------

                           ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM          RANGE          MIDRANGE



DIFF(ppb)            6.13150         -2.51790        8.64940           1.80680
-----------------------------------------------------------------------------------
```

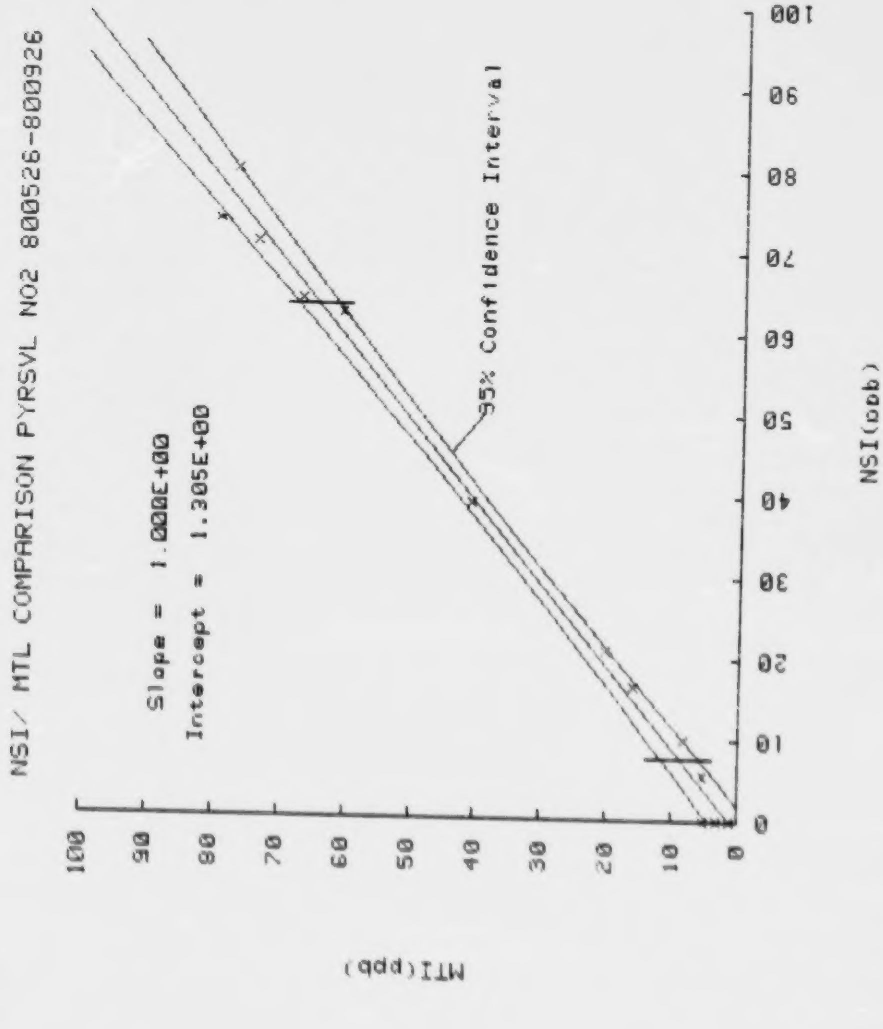

Figure 19. Estimated line of best fit: Audit of Perrysville station for nitrogen dioxide.

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TABLE 16. SUMMARY: AUDIT OF PERRYSVILLE STATION FOR SULFUR DIOXIDE

```
          Variable # 1   Variable # 2   Variable # 3
OBS#
   1
             0.00000       -5.90000       -5.90000
   2
            80.00000       87.70000        7.70000
   3
            64.00000       69.50000        5.50000
   4
            32.30000       28.00000       -4.30000
   5
            16.20000        5.60000      -10.60000




                             BASIC STATISTICS

VARIABLE     # OBSERVATIONS    # MISS. VALUES            SUM             MEAN
DIFF(ppb)                5                  0       -7.60000         -1.52000
-----------------------------------------------------------------------------
                                                     COEF OF          COEF OF
VARIABLE           VARIANCE     STANDARD DEV.       SKEWNESS         KURTOSIS
DIFF(ppb)          60.91200           7.80461         .16204         -1.57826
-----------------------------------------------------------------------------
                                STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION       OF THE MEAN     LOWER LIMIT       UPPER LIMIT
DIFF(ppb)         513.46145           3.49033       -11.21113          8.17113
-----------------------------------------------------------------------------

                             ORDER STATISTICS


VARIABLE            MAXIMUM           MINIMUM          RANGE         MIDRANGE
DIFF(ppb)           7.70000         -10.60000       18.30000         -1.45000
-----------------------------------------------------------------------------
```

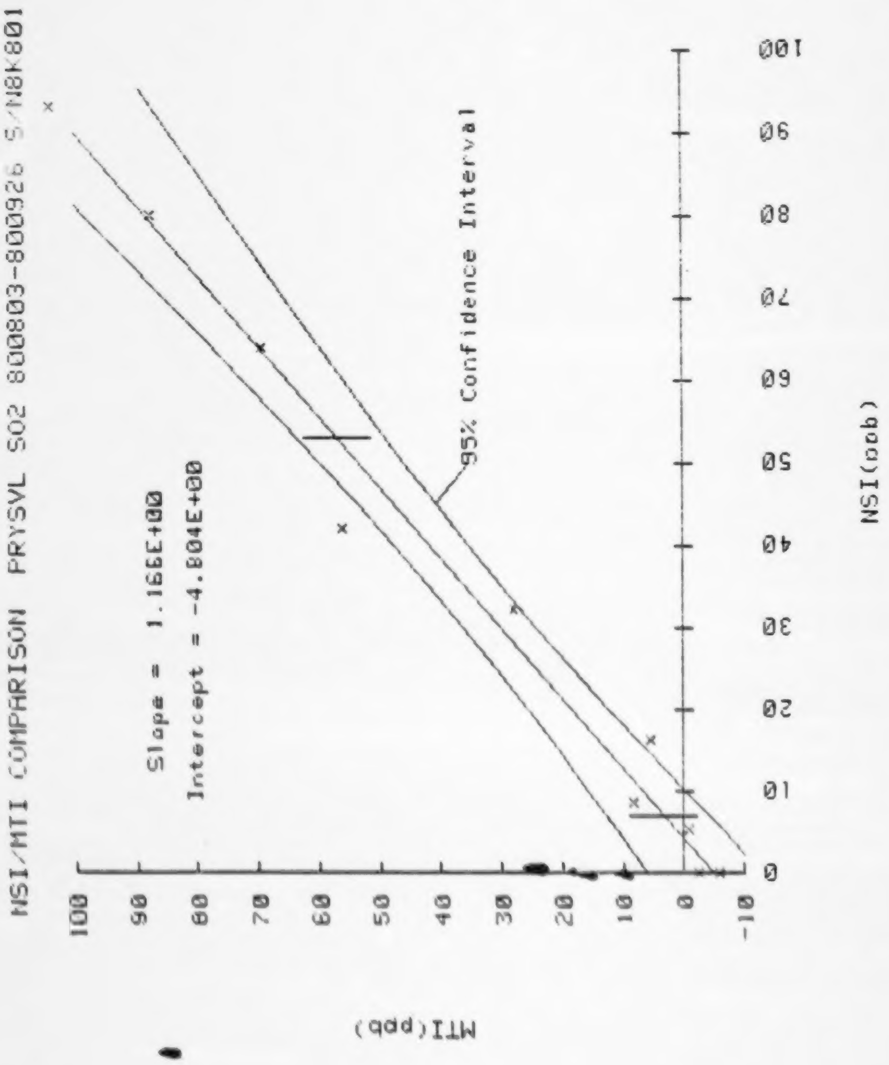

Figure 20. Estimated line of best fit: Audit of Perrysville station for sulfur dioxide.

TABLE 17. STATION GRADES: CONTINUOUS ANALYZERS

Station	Pollutant	Standard Deviation (NSI-ES)*	Standard Deviation (MTL)†	Grade‡
Morganfield	O_3	2.575	8.449	77.2
	NO	1.254	3.932	78.6
	NO_2	1.572	7.326	63.4
	SO_2	1.235	6.302	59.0
Brookville	O_3	2.575	8.955	75.2
	NO	1.254	1.613	97.1
	NO_2	1.572	2.867	91.8
	SO_2	1.235	3.834	79.0
Perrysville§	O_3	2.575	4.182	66.6
	NO	1.254	4.403	74.9
	NO_2	1.572	2.720	92.7
	SO_2	1.235	7.805	46.8

*Standard deviation of the difference (ppb), Variable #3, NSI-ES versus QAD, as determined in the QAD audit certification comparisons.

†Standard deviation of the difference (ppb), Variable #3, NSI-ES versus MTL, as determined in the audits of the ORV stations.

‡Grades were calcuated as described in Section 5.

§Results for Perrysville SO_2 are for one audit only (August 8, 1980). This analyzer was nonoperational on the other two audits.

TABLE 18. STATION GRADES:
PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

Station	Instrument*	Mean Percent Difference	Grade†
Morganfield	high volume sampler		
	nephelometer	2.6	94.8
	dichotomous sampler	4.3	91.4
	temperature sensor	3.5	93
	barometer	0.3	99.4
	wind direction sensor	0.0	-
	dew point sensor	12.7	74.6
Brookville	high volume sampler		
	nephelometer	2.5	95.0
	dichotomous sampler	2.9	94.2
	temperature sensor	5.5	89.0
	barometer	0.2	99.6
	wind direction sensor	0.0	-
	dew point sensor	13.0	74
Perrysville	high volume sampler		
	nephelometer	1.2	97.6
	dichotomous sampler	4.4	91.2
	temperature sensor	8.7	82.6
	barometer	0.3	99.4
	wind direction sensor	0.0	-
	dew point sensor	33.0	44

*Grades are not given for the wind direction sensor. However, the audit values obtained for this instrument were within the limits of measurement for the audit device (±10°); thus, for purposes of comparison, a grade of 100 would be assigned.

†Grades were calculated as described in Section 5.

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APPENDIX A

QAD STATEMENTS OF AUDIT CERTIFICATION COMPARISON RESULTS

ENVIRONMENTAL PROTECTION AGENCY

June 4, 1980

Mr. Joe Williams
Northrop Services, Inc.
P.O. Box 12313
Research Triangle Park, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3 and SO_2 system with our laboratory system on March 19, 1980.

Gas - O_3

QAD (ppm)	Northrop (ppm)
0.000	0.000
.025	.028
.095	.100
.126	.124
.158	.159
.201	.194

Northrop = .9617 QAD + 0.00320 R^2 = .9999

Gas - NO

QAD (ppm)	Northrop (ppm)
0.000	0.000
.085	.088
.044	.044
.011	.011
.006	.006

Northrop = 1.03495 QAD - 0.00050 R^2 = .9999

Gas - NO_2

QAD (ppm)	Northrop (ppm)
0.000	0.000
.070	.071
.056	.056
.037	.039
.016	.014

Northrop = 1.0234 QAD - 0.00063 R^2 = .9999

Gas - SO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.0723	.076
	.0380	.0378
	.0140	.0163
	.002	.004

Northrop = 1.0338 QAD + 0.00110 $R^2 = .9999$

On the day of the comparison, the QAD system showed the following agreement.

$[NO_2]GPT\text{-}NO = 1.02136\ [NO_2]Pd + 0.00362$ $R^2 = .9999$

$[O_3]GPT\text{-}NO = 1.040\ [O_3]UV - 0.00503$ $R^2 = .9999$

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: Jack Puzak
Ralph Baumgardner
Jack Bowen

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

August 5, 1980

Mr. Joe Williams
Northrop Services
P.O. Box 12313
Research Triangle Park, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3, and SO_2 audit system with our laboratory system on July 10, 1980.

Gas - NO	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.082	.084
	.063	.064
	.041	.043
	.020	.021
	.010	.010

Northrop = 1.0221 QAD + 0.0002 R^2 = .9998

Gas - NO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.062	.066
	.056	.060
	.036	.037
	.016	.019

Northrop = 1.0513 QAD - 0.0003 R^2 = .9994

Gas - O_3	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.185	.186
	.154	.154
	.066	.062
	.018	.019

Northrop = 1.004 QAD - 0.007 R^2 = .9996

Gas - SO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.079	.080
	.063	.064
	.032	.032
	.015	.016

Northrop = 1.0101 QAD + 0.0002 R^2 = .9999

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

Jack O. Bowen for

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: Jack Puzak
Ralph Baumgardner
Jack Bowen

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UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

September 15, 1980

Mr. Joe Williams
Northrop Services, Inc.
P.O. Box 12313
Research Triangle Park, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3, and SO_2 audit systems with the QAD audit verification systems on September 10-11, 1980.

Gas - SO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	0.0793	0.0800
	0.0455	0.0458
	0.0090	0.0091
	0.0051	0.0050

NSI = 1.0091 QAD - 0.00005 $R^2 = .9999$

Gas - O_3	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.179	.176
	.085	.085
	.034	.035
	.013	.013

NSI = .9821 QAD + 0.0007 $R^2 = .9999$

Gas - NO	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.082	.085
	.047	.049
	.010	.099
	.0045	.0049

NSI = 1.0399 QAD - 0.00014 $R^2 = .9999$

Gas - NO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.072	.076
	.051	.053
	.023	.025
	.007	.008

NSI = 1.0455 QAD + 0.0004 $R^2 = .9998$

If you have any questions, please contact me.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: J.C. Puzak
R.E. Baumgardner
J.A. Bowen

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

October 14, 1980

Mr. Joe Williams
Northrop Services
P.O. Box 12313
RTP, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3 and SO_2 audit system with our laboratory system on October 7, 1980.

Gas - NO	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.085	.089
	.052	.053
	.010	.010
	.006	.006

Northrop = 1.0443 QAD - 0.0004 R^2 = .9998

Gas - NO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.074	.076
	.053	.054
	.015	.017
	.006	.008

Northrop = 1.008 QAD + 0.0011 R^2 = .9996

Gas - O_3	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.181	.177
	.087	.088
	.035	.036
	.015	.014

Northrop = .9802 QAD + 0.0006 R^2 = .9991

Gas - SO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.0850	.0890
	.0390	.0408
	.0065	.0080
	.0040	.0053

Northrop = 1.0373 QAD + 0.0007 $R^2 = .9999$

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: J. Puzak
R. Baumgardner
J. Bowen

APPENDIX B

RESULTS OF STATION AUDITS

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
062126	Morganfield	NEPHELOMETER	Operational	BACKGROUND	0.0 V	0.32 V	----	
	Kentucky	(MRI)		Cal	4.000 V	4.350 V	8.8	
				dark	0.0 V	0.005 V	----	
				Freon	1.100 V	1.180 V	7.3	
	Morganfield	DICHOTOMOUS	Operational	Total Flow	16.71 l/min	16.63 l/min	-0.4	
	Kentucky	(Beckman)		Fine Flow	15.0 l/min	14.68 l/min	2.1	
				Coarse Flow	1.70 l/min	1.95 l/min	14.7	
	Morganfield	CLIMET	Operational	Temp.	23.85°C	24.7°C		
	Kentucky			Barometer		749.1		
				Wind Dir.	160° ± 10°	162°		
				Wind Speed				
				Dewpoint	17.2°C	15.5°C		
				Solar Radiation				
06103	Brookville	NEPHELOMETER	Operational	BACKGROUND	0.0 V	0.013 V	----	
	Indiana	(MRI)		Cal	4.000 V	3.920 V	2.0	
				dark	0.0 V	0.007 V	----	
				Freon	1.1 V	1.08 V	-1.8	
	Brookville	DICHOTOMOUS	Operational	Total Flow	16.70 l/min	16.53 l/min	-1.0	Pressure switch too sensitive
	Indiana	(Beckman)		Fine Flow	15.00 l/min	15.10 l/min	0.7	
				Coarse Flow	1.70 l/min	1.43 l/min	-15.9	

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
		NEPHELOMETER		BACKGROUND				
	Brookville Indiana	CLIMET	Operational	Temp.	26°C	24.9°C	4.4	
				Barometer		733.83		
				Wind Dir.	330° ± 10°	330°		
				Wind Speed				
				Dewpoint	18.4°C	15.7°C		
				Solar Radiation				
062042	Perrysville Ohio	NEPHELOMETER (MRI)	Operational	BACKGROUND	0.0 V	-0.033 V	----	
				Cal	4.000 V	3.940 V	-1.5	
				dark	0.0	0.008 V	----	
				Freon	1.1	1.076 V	2.2	
	Perrysville Ohio	DICHOTOMOUS (Beckman)	Operational	Total Flow	16.7 l/min	15.3 l/min	-8.4	
				Fine Flow	15.0 l/min	13.5 l/min	-9.9	
				Coarse Flow	1.7 l/min	1.8 l/min	5.9	
	Perrysville Ohio	CLIMET		Temp.	19.6°C	22.8°C	16.3	
				Barometer		730.5		
				Wind Dir.	340° ± 10°	340°		
				Wind Speed				
				Dewpoint	4.4°C	0.5°C		
				Solar Radiation				

CONTINUOUS ANALYZERS

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE		REGRESSION OF ANALYZER RESPONSE		
						ppb	PERCENT	m	b	r
062120	Morganfield Kentucky	Bendix 13162-1	O_3	0	1.0	---	---	1.1154	-0.1184	0.9996
				0.3	0.3	0.0	0.0			
				19	22	3.0	15.8			
				40	41	1.0	2.5			
				114	130	16.0	14.0			
				168	186	18.0	10.7			
062103	Brookville Indiana	Bendix 13162-2	O_3	0	2	---	---	1.040	-0.0008	0.9993
				181.0	191.0	10.0	5.5			
				135.0	136.0	1.0	0.7			
				49.0	48.2	-0.8	-1.6			
				17.0	17.0	0.0	0.0			
062042	Perrysville Ohio	Bendix 13162-3	O_3	0	-1.0	---	---	1.0390	-0.5975	0.9992
				181.0	188.0	7.0	3.9			
				143.0	145.0	2.0	1.4			
				62.0	59.6	-2.4	-3.9			
				14.0	12.4	-1.6	-11.4			

CONTINUOUS ANALYZERS

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb	PERCENT	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Morganfield Kentucky	CSI 9895	NO	0.0	1.0	---	---	1.1499	-0.0545	0.9998
				88.0	101.0	13.0	14.8			
				44.0	51.1	7.1	16.1			
				11.2	12.2	1.0	8.9			
				6.0	6.0	0.0	0.0			
062103	Brookville Indiana	CSI 9707	NO		DOWN					
062042	Perrysville Ohio	CSI 9894	NO	0.0	-1.7	---	---	1.035	-2.635	0.9997
				88.0	88.0	0.0	0.0			
				44.0	44.0	0.0	0.0			
				11.2	8.5	-2.7	-24.1			
				6.0	2.4	-3.6	-60.0			

CONTINUOUS ANALYZERS

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb	PERCENT	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Morganfield Kentucky	CSI 9895	NO_x	0.0	1.0	---	---	1.059	-0.1065	0.9998
				88.0	93.0	5.0	5.7			
				44.0	46.8	2.8	6.4			
				11.2	11.3	0.1	1.1			
				6.0	5.3	-0.7	11.7			
062103	Brookville Indiana	CSI 9707	NO_x		DOWN					
062042	Perrysville Ohio	CSI 9894	NO_x	0.0	-1.5	---	---	1.0193	-2.1553	0.9997
				88.0	87.0	-1	1.1			
				44.0	44.0	0.0	0.0			
				11.2	9.0	-2.2	-19.6			
				6.0	2.8	-3.2	-53.3			

CONTINUOUS ANALYZERS

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE		REGRESSION OF ANALYZER RESPONSE		
						ppb	PERCENT	m	b	r
062126	Morganfield Kentucky	CSI 9895	NO_2	0.0	1.0	---	---	1.006	-4.1521	0.9952
				72.0	76.8	4.8	6.6			
				59.0	61.0	2	3.4			
				38.0	36.0	-2	-5.3			
				14.0	9.0	-5	-35.7			
				13.0	7.0	-6	-46.1			
062103	Brookville Indiana	CSI 9707	NO_2		DOWN					
062042	Perrysville Ohio	CSI 9894	NO_2	0.0	5.0	---	---	0.9781	1.1149	0.9964
				71.0	71.0	0.0	0.0			
				64.0	64.3	0.3	0.4			
				39.0	39.4	0.4	1.0			
				21.0	19.5	-1.5	-7.1			
				10.0	8.0	-2.0	-20.0			

CONTINUOUS ANALYZERS

23 MAY - 26 MAY, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	Meloy 8L049	SO_2	NONOPERATIONAL - NONLINEAR RESPONSE					
062103	Brookville Indiana	Meloy 5L042	SO_2	NONOPERATIONAL - PMT COOLER DOWN					
062042	Perrysville Ohio	Meloy 8K08	SO_2	NONOPERATIONAL - INADEQUATE HYDROGEN FLOW					

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

30 JUNE - 2 AUGUST, 1980

TION MBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
126	Morganfield Kentucky	NEPHELOMETER (MRI)	Operational	BACKGROUND	0.0 V	- 0.001 V	-	
				Cal	4.000 V	4.000 V	0.0	
				dark	0.0 V	0.001 V	-	
				Freon	1.1 V	1.037 V	- 5.7	
	Morganfield Kentucky	DICHOTOMOUS (Beckman)	Operational	Total Flow	16.7 ℓ/m	16.70 ℓ/m	0.0	
				Fine Flow	15.0 ℓ/m	15.34 ℓ/m	2.3	
				Coarse Flow	1.70ℓ/m	1.36 ℓ/m	- 20.0	
	Morganfield Kentucky	CLIMET	Operational	Temp.	32.0°C	32.4°C	- 1.	
				Barometer	750.5 mmHg	754.0 mmHg	.5	
				Wind Dir.	238° ± 5°	226°	-	
				Wind Speed				
				Dewpoint	22.0° C	21.0° C	-4.5	
				Solar Radiation				
103	Brookville Indiana	NEPHELOMETER (MRI)	Operational	BACKGROUND	0.0 V	0.005 V	-	
				Cal	4.000 V	4.340 V	8.5	
				dark	0.0 V	0.009 V	-	
				Freon	1.200 V	1.110 V	- 7.5	
	Brookville Indiana	DICHOTOMOUS (Beckman)	Operational	Total Flow	16.7 ℓ/m	16.3 ℓ/m	- 2.4	
				Fine Flow	15.0 ℓ/m	14.6 ℓ/m	- 2.7	
				Coarse Flow	1.7 ℓ/m	1.7 ℓ/m	0.0	

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
	Brookville Indiana	CLIMET		Temp.	26.5	26.0	- 1.8	
				Barometer	738 mm Hg	740 mm Hg	.3	
				Wind Dir.	238 ± 5°	227°		
				Wind Speed				
				Dewpoint	20.1° C	19.1° C	- 5.0	
				Solar Radiation				
062042	Perrysville Ohio	NEPHELOMETER (MRI)		BACKGROUND	0.0 V	0.091 V	-	
				Cal	4.0 V	3.985 V	- .4	
				dark	0.0 V	0.003 V	-	
				Freon	1.20 V	1.173 V	-2.3	
	Perrysville Ohio	DICHOTOMOUS (Beckman)		Total Flow	16.7 ℓ/m	16.2 ℓ/m	-3.0	Pressure Switch
				Fine Flow	15.0 ℓ/m	14.6 ℓ/m	-2.7	Malfunctioned
				Coarse Flow	1.7 ℓ/m	1.6 ℓ/m	-5.9	
	Perrysville Ohio	CLIMET		Temp.	30.5° C	29.5°C	-3.3	
				Barometer	721.5mm Hg	723.5mm Hg	.3	
				Wind Dir.	229°	225°	-	
				Wind Speed			-	
				Dewpoint	23.4	22.5	-3.8	
				Solar Radiation				

CONTINUOUS ANALYZERS

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	Bendix 13162-N	O_3	0.0	- .5	-	1.024	-.6656	.9999
				163	167.0	7.1			
				125	127.0	1.6			
				48	47.0	- 2.1			
				9	9.6	6.7			
062103	Brookville Indiana	Bendix 13162-2	O_3	0.0	0.0	-	1.0757	-.3318	.9989
				173.0	183.0	5.8			
				105.0	116.0	10.5			
				49.0	56.0	14.3			
				12.0	8.0	-33.			
062042	Perrysville Ohio	Bendix 13162-3	O_3	0.0	.3	-	1.23	- 5.18	.9987
				145.0	175.0	20.7			
				108.0	126.0	16.7			
				44.0	49.4	12.3			
				13.4	5.3	-60.5			

CONTINUOUS ANALYZERS

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUD. LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	CSI 9895	NO	0.0	2.4	-	.9654	2.330	.9999
				84.0	83.5	- .6			
				43.0	43.7	1.6			
062103	Brookville Indiana	CSI 9707	NO	0.0	0.2	-	.9617	.3160	.9999
				84.0	81.2	- 3.3			
				64.0	62.0	- 3.1			
				43.0	41.2	- 1.9			
				21.0	20.5	- 2.4			
				10.0	10.3	3.0			
062042	Perrysville Ohio	CSI 9939	NO	0.0	.3	-	1.1766	.9584	.9997
				84.0	99.1	18.0	(Remarks)		
				43.0	52.9	23.0	10 ppb Oscillations		
							visible on strip chart		
							prior to audit.		
							New Analyzer Installed		
							only two days.		

CONTINUOUS ANALYZERS

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Morganfield Kentucky	CSI 9895	NO_x	0.0	1.4	-			
				84.0	77.0	- 8.3	.8732	3.6536	1.0000
				43.0	41.2	- 6.5			
062103	Brookville Indiana	CSI 9707	NO_x	0.0	- 1.8	-	.9841	-.3465	.9996
				84.0	82.2	- 2.1			
				64.0	62.4	- 2.5			
				43.0	41.8	- 2.8			
				21.0	21.5	2.4			
				10.0	10.3	3.0			
062042	Perrysville Ohio	CSI 9939	NO_x	0.0	3.6	-	1.1057	3.2239	.9999
				84.0	96.5	14.9			
				43.0	50.0	16.3			

CONTINUOUS ANALYZERS

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUD. LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION O. .ALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	CSI 9895	NO_2	0.0	3.7	-			
				80.3	70.3	- 12.5	.8437	2.1218	.9987
				60.3	53.4	- 11.4			
				53.3	46.9	- 12.0			
				21.8	18.3	- 16.1			
062103	Brookville Indiana	CSI 9707	NO_2	0.0	1.7	-	.9619	2.8	.9989
				66.4	66.2	- 0.3			
				39.3	41.7	6.1			
				17.2	18.3	6.4			
				4.9	9.1	85.7			
062042	Perrysville hio	CSI 9939	NO_2	0.0	3.3	-	1.0435	3.3	1.000
				73.6	80.1	8.8			

CONTINUOUS ANALYZERS

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUD. LEVEL ppb	ANALYZER RESPONSE	DIFFERENCE ppb PERCENT	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062120	Morganfield Kentucky	Meloy 8L049	Sulfur						
				0.0	+ 2.3	-	1.2318	-4.6049	.9990
				80.0	95.1	18.9	(Remarks)		
				64.0	74.2	15.9	High Voltage test		
				32.3	33.0	2.2	Offscale		
				16.2	14.1	13.0			
062103	Brookville Indiana	Meloy 5L042	Sulfur	0.0	- 6.7	-	1.0926	- 9.0052	.9980
				80.0	78.0	- 2.5	(Remarks)		
				64.0	62.0	- 3.1	High Voltage test		
				32.3	27.0	-16.4	Offscale		
				16.2	5.0	-69.1			
062042	Perrysville Ohio	Meloy 8K801	Sulfur	0.0	- 5.9	-	1.2164	-9.8504	.9971
				80.0	87.7	9.6	(Remarks)		
				64.0	69.5	8.6	High Voltage test		
				32.3	28.0	-13.3	Offscale		
				16.2	5.6	-65.4	Amplifier test offscale		

HIGH VOLUME SAMPLER

30 JUNE - 2 AUGUST, 1980

STATION NUMBER	STATION NAME	HI-VOL	AUDIT LEVEL	RESPONSE	DIFFERENCE PERCENT	REGRESSION OF RESPONSE		
			(ft^3/min)	(ft^3/min)		m	b	r
062126	Morganfield Kentucky		59.7	63	5.5	1.2878	-13.9195	0.9949
			55.0	55.6	1.1			
			49.0	49.9	1.8			
			40.8	40.6	-0.5			
			32.5	26.5	-18.5			
062103	Brookville Indiana		65.8	61.6	-6.4	0.9166	1.2312	0.9999
			59.0	55.4	-6.1			
			52.5	49.1	-6.5			
			43.11	40.8	-5.4			
			34.5	32.9	-4.6			
062042	Perrysville Ohio		59.1	55.8	-5.6	0.6786	15.1109	0.9985
			54.9	51.7	-5.8			
			48.1	47.6	-1.0			
			39.4	42.1	6.9			
			28.3	34.3	21.2			

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
062126	Morganfield Kentucky	NEPHELOMETER (MRI)	Operative	BACKGROUND	0.000V	0.014V	[illegible]	
				Cal	4.000V	4.080V		
				dark	0.000V	0.008V	.1	
				Freon	1.200V	1.207V	[illegible]	
	Morganfield Kentucky	DICHOTOMOUS (Beckman)	Operative	Total Flow	16.7 1/m	16.7 1/m	0.0	
				Fine Flow	15.0 1/m	15.0 1/m	0.0	
				Coarse Flow	1.7 1/m	1.7 1/m	0.0	
	Morganfield Kentucky	CLIMET	Operative	Temp.	18.5°C	17.4°C	[illegible]	
				Barometer	756.8	755.0	[illegible]	
				Wind Dir.				
				Wind Speed	356.± 10	349.	[illegible]	
				Dewpoint	15.1	11.5	[illegible]	
				Solar Radiation				
06103	Brookville Indiana	NEPHELOMETER (MRI)	Inoperative	BACKGROUND				
				Cal				
				dark				
				Freon				
	Brookville Indiana	DICHOTOMOUS (Beckman)	Operative	Total Flow	16.7 1/m	16.4 1/m	-1.8	
				Fine Flow	15.00 1/m	14.7 1/m	-2.0	
				Coarse Flow	1.7 1/m	1.7 1/m	[illegible]	

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
	Brookville Indiana	CLIMET		Temp.	21.5°C	19.3°C	-10.2	
			Operative	Barometer	738.5	741.1	.4	
				Wind Dir.	362 ± 10	357	[illegible]	
				Wind Speed				
				Dewpoint	13.0°C	10.5°C	-19.2	
				Solar Radiation				
062042	Perrysville Ohio	NEPHELOMETER (MRI)	Inoperative	BACKGROUND				
				Cal				
				dark				
				Freon				
	Perrysville Ohio	DICHOTOMOUS (Beckman)		Total Flow	16.7	16.4	-1.8	
				Fine Flow	1.7	1.7	[illegible]	
				Coarse Flow	15.0	14.7	[illegible]	
	Perrysville Ohio	CLIMET		Temp.	19.8	18.5	-6.6	
				Barometer	729.5	727	-0.3	
				Wind Dir.	140 ± 10	150	[illegible]	
				Wind Speed				
				Dewpoint	15.1	13.9	-7.9	
				Solar Radiation				

CONTINUOUS ANALYZERS

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	Bendix 13162-1	O_3	153.0	158.0		1.0325	0.3997	.9998
				63.0	66.4				
				24.0	24.2				
				12.0	14.6				
				0.0	-1.0				
062103	Brookville Indiana	Bendix 13162-2	O_3	158.0	156.0	NSI UV	.9502	-1.1766	.9790
				66.0	68.0	photometer			
				39.0	40.6	erratic			
				18.0	20.6				
				5.0	7.0				
				0.0	1.0				
062042	Perrysville Ohio	Bendix 13162-3	O_3	180.0	162.0	Operators	.8970	-.4192	.9998
				76.0	66.0	transfer			
				45.0	39.0	standard			
				21.0	18.2	disagrees			
				7.0	7.0	with NSI			
				0.0	0.4	standard			

CONTINUOUS ANALYZERS

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	CSI 9895	NO	93.0	92.1		.9746	1.3764	.9999
				52.0	52.0				
				10.6	11.5				
				5.4	6.2				
				0.0	2.0				
062103	Brookville Indiana	CSI 9939	NO	84.4	82.0		.9562	1.5221	.9999
				52.0	51.7				
				10.3	11.1				
				6.4	7.3				
				0.0	1.9				
062042	Perrysville Ohio	CSI 9894	NO	88.0	88.7		.9750	2.7226	.9998
				55.0	56.1				
				11.0	12.6				
				6.8	10.5				
				0.0	2.5				

CONTINUOUS ANALYZERS

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield	CSI	NO_x						
	Kentucky	9895		93.0	91.3		.9065	6.95	.9999
				52.0	53.9				
				10.6	16.9				
				5.4	12.2				
				0.0	6.4				
062103	Brookville	CSI	NO_x	84.4	82.2	Noise ± 2ppb	.942	2.7164	.9998
	Indiana	9939		52.0	51.9	New analyzer			
				10.3	11.6	replaced			
				6.4	8.7				
				0.0	3.4	SIN9707			
062042	Perrysville	CSI	NO_x	88.0	88.7		.9721	3.6957	.9998
	Ohio	9894		55.0	57.9				
				11.0	14.7				
				6.8	10.9				
				0.0	2.6				

CONTINUOUS ANALYZERS

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	CSI 9895	NO_2	83.8	68.4		.8169	-1.6316	.9893
				44.3	56.8				
				21.1	12.7				
				9.4	1.6				
				0.0	4.7				
062103	Brookville Indiana	CSI 9939	NO_2	68.4	64.5		.9160	.4991	.9993
				62.0	56.0				
				18.4	16.8				
				5.8	5.4				
				0.0	1.4				
062042	Perrysville Ohio	CSI 9894	NO_2	79.7	75.3		.9399	.5341	.9999
				62.3	59.4				
				16.6	15.8				
				5.5	5.2				
				0.0	1.2				

CONTINUOUS ANALYZERS

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUD. LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION O. ALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	Meloy 8L049	SO_2						
				91.0	93.4		1.0023	-0.5343	.9965
				52.7	48.0				
				12.3	10.4				
				5.6	4.2				
				0.0	3.3				
062103	Brookville Indiana	Meloy 5L042	SO_2	88.8	89.0				
				40.8	40.9				
				-----	-----				
062042	Perrysville Ohio	Meloy 8K801	SO_2	93.0	104.0	Inoperative	1.1800	-2.1033	.9934
				42.0	56.1	P.M. Tube Voltage			
				8.7	8.3	Fluctuating			
				5.3	- .8				
				0.0	-2.3				

HIGH VOLUME SAMPLER

22 SEPTEMBER - 26 SEPTEMBER, 1980

STATION NUMBER	STATION NAME	HI-VOL	AUDIT LEVEL	RESPONSE	DIFFERENCE PERCENT	REGRESSION OF RESPONSE m	b	r
062126	Morganfield Kentucky		59.8	59.7	.17	.7091	4.1175	.9763
			54.2	52.0	-4.1			
			47.6	46.5	-2.3			
			33.6	[illegible]	13.7			
			32.2	30.7	-4.7			
062103	Brookville Indiana		64.6	62.2	-3.7	1.0097	-3.9768	.9976
			57.2	52.9	-7.5			
			50.5	46.9	-7.1			
			41.6	37.2	-10.6			
			33.1	30.3	-8.5			
062042	Perrysville Ohio		56.7	61.4	8.1	1.4260	-19.9606	.9768
			51.2	55.4	8.2			
			47.4	47.9	1.1			
			43.3	36.9	-14.7			
			32.2	28.0	-13.0			

TN-81-06
October 1981

SUMMARY OF AUDITS
OF THE OHIO RIVER VALLEY AIR MONITORING STATIONS

by

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DISCLAIMER

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FOREWORD

This report presents the results of work performed by Northrop Services, Inc. - Environmental Sciences, under Contract 68-02-3285 for the Inorganic Pollutant Analysis Branch, Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, during the period November 1980 to March 1981. Work was completed as of March 21, 1981.

ABSTRACT

Three audits of the Ohio River Valley Air Monitoring Study stations were conducted during the period November 1980 to March 1981. Equipment audited at each station included a Climet meteorological system, dichotomous sampler, high volume sampler, integrating nephelometer, chemiluminescent ozone analyzer, flame photometric total sulfur analyzer, and chemiluminescent oxides of nitrogen analyzer. Each standard and flow measurement device used in the audits was traceable to a Standard Reference Material of the National Bureau of Standards.

Before each audit, verification audits were conducted in the facility of the Quality Assurance Division of the Environmental Monitoring Systems Laboratory (EPA-ORD-RTP).

Results for all three audits are summarized and compared to results of the verification audits. As a basis for discussion, the monitoring stations are assigned grades in accordance with designated performance criteria.

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SECTION 1

INTRODUCTION

The Ohio River Valley (ORV) Study was initiated to measure low level background concentrations of gaseous and particulate pollutants. Northrop Services, Inc. - Environmental Sciences (NSI-ES) designed and constructed the stations and is responsible for external quality assurance. The stations are operated by Mead Technology Laboratories (MTL).

During the period November 1980 to March 1981, NSI-ES conducted 3 performance audits of the ORV stations at bimonthly intervals. The purposes of this series of audits were:

1) To determine the accuracy of individual sensors at given points in time
2) To identify and report in a timely manner each sensor system found to be outside acceptable limits so that MTL could take immediate corrective action

Each standard and flow measurement device used to perform the audits was referenced to a National Bureau of Standards (NBS) Standard Reference Material (SRM) or to a secondary standard traceable to an NBS SRM.

The stations are located in rural areas near Morganfield, Kentucky (Union County); Brookville, Indiana (Franklin County); and Perrysville, Ohio (Ashland County). Two of the stations are on working farms and the third is in a state park. Each station contains a Climet meteorological system that reports wind speed, wind direction, barometric pressure, temperature, dew point, and solar radiation (as measured by an Eppley solar radiometer). The particulate measurement system consists of a Beckman dichotomous sampler, General Metal Works high volume sampler, and Meteorology Research Inc. integrating nephelometer. Each station also contains three continuous analyzers: a Bendix chemiluminescent ozone analyzer, Meloy flame photometric total sulfur analyzer, and Columbia Scientific chemiluminescent oxides of nitrogen analyzer. Each station also has a gas chromatograph for sampling peroxyacetyl nitrate (PAN) and a high volume sampler with Tenax cartridge system downstream from the particulate filter to sample for organic pollutants.

SECTION 2

AUDIT DEVICES AND STANDARDS

CONTINUOUS ANALYZERS

Ozone

The chemiluminescent O_3 analyzer was audited using an ultraviolet (UV) photometric calibration system (Figure 1). In this system, the concentration of O_3 in an absorption cell is determined from a measurement of the amount of 254 nm light absorbed by the sample (i.e., the transmittance of the sample):

$$T = I/Io = e^{-\alpha c l}$$

where c = concentration of O_3

α = absorption coefficient of O_3

l = pathlength

Stable O_3 concentrations were generated with a dynamic dilution/gas phase titration (GPT) system which produces O_3 by UV irradiation of air using a shielded mercury lamp. Upscale concentrations are generated by varying the length of time the lamp is exposed to the air and the total flow of dilution air.

Oxides of Nitrogen

The NO and NO_2 channels were audited using a dilution/GPT system, a cylinder containing 2.95 ppm NO, and a cylinder of zero air used for dilution. The flow rates from the NO cylinder were varied to generate the upscale audit points. The NO cylinder concentration was determined by referencing to an NBS SRM. All flow rates were measured using a Hastings bubble meter referenced to NBS burettes.

Total Sulfur

The sulfur analyzer was audited using a cylinder containing SO_2. Zero air containing ~350 ppm CO_2 was used for dilution. The flow rate from the SO_2 cylinder was varied to generate upscale audit points. The SO_2 cylinder concentration was determined by referencing to an NBS SRM. All flow rates were measured using a Hastings bubble meter referenced to NBS burettes.

DILUTION/GAS PHASE TITRATION AUDIT SYSTEM

The dilution/GPT system is shown in Figure 2. The system is equipped with Tylan mass flow controllers which will maintain mass flow to within ±0.25% of

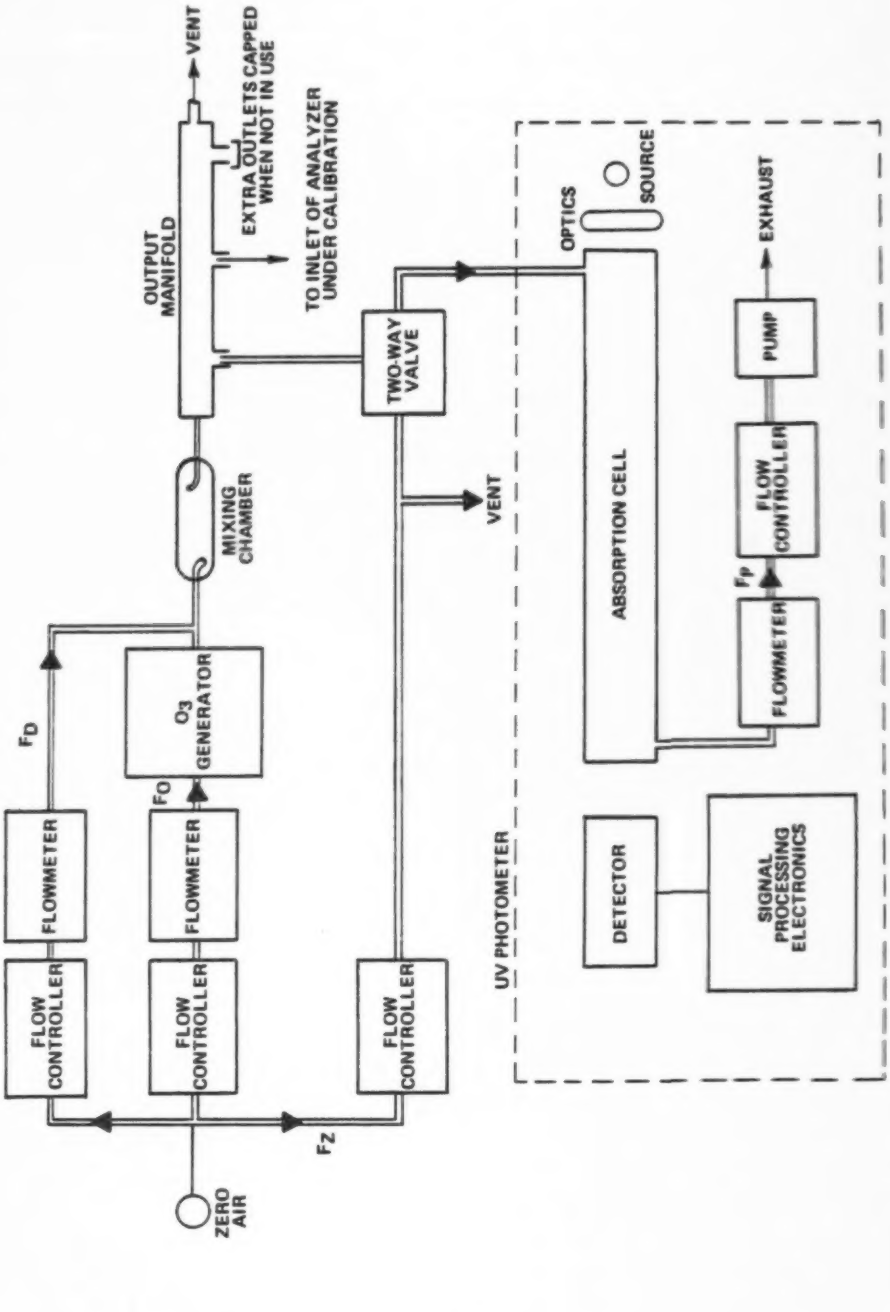
ZERO AIR
FZ
FLOW CONTROLLER
FLOWMETER
FD
FLOW CONTROLLER
FLOWMETER
FO
O3 GENERATOR
MIXING CHAMBER
OUTPUT MANIFOLD
VENT
EXTRA OUTLETS CAPPED WHEN NOT IN USE
TO INLET OF ANALYZER UNDER CALIBRATION
FLOW CONTROLLER
VENT
TWO-WAY VALVE
UV PHOTOMETER
OPTICS
SOURCE
ABSORPTION CELL
DETECTOR
SIGNAL PROCESSING ELECTRONICS
FLOWMETER
FP
FLOW CONTROLLER
PUMP
EXHAUST

Figure 1. Schematic diagram of UV photometric calibration system.

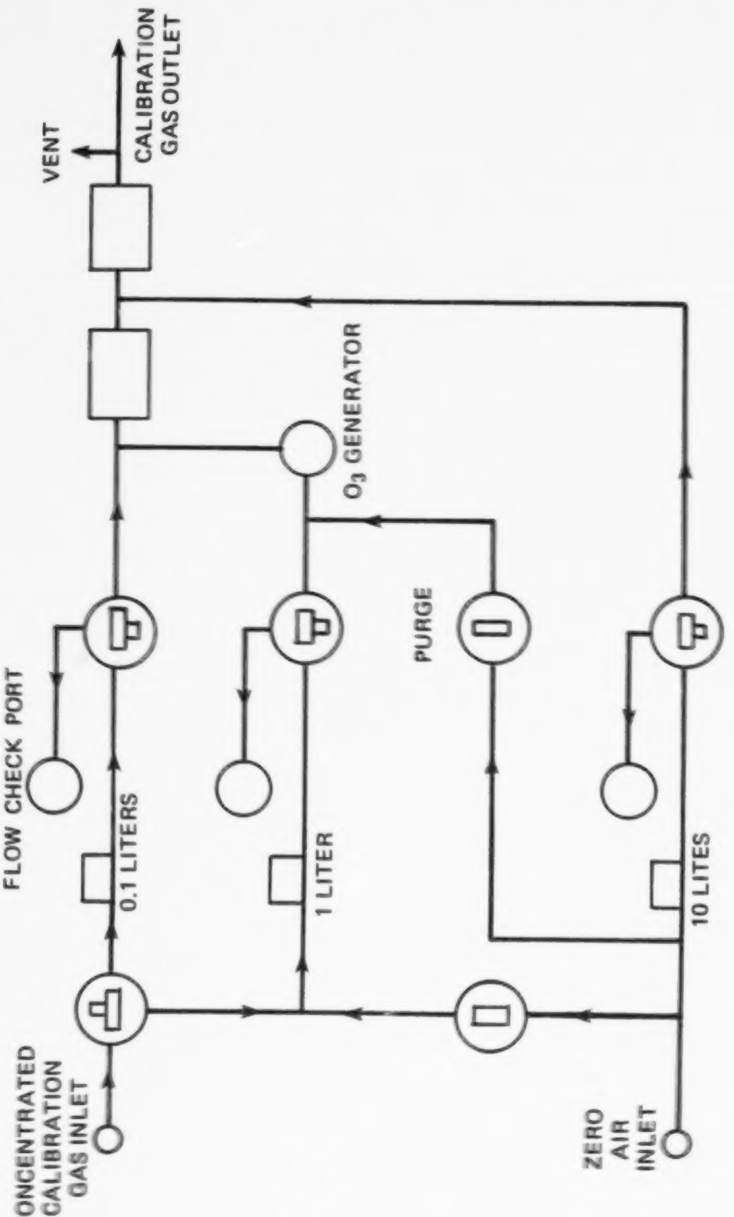
CALIBRATION GAS OUTLET
VENT
O_3 GENERATOR
FLOW CHECK PORT
PURGE
0.1 LITERS
1 LITER
10 LITES
CONCENTRATED CALIBRATION GAS INLET
ZERO AIR INLET

Figure 2. Dilution/gas phase titration audit system.

the setting. All fittings and other components which come in contact with oxidizing gases are stainless steel, Teflon, or glass. All flow rates are fully controllable; the dilution airflow, pollutant flow, and flow through the O_3 generators are maintained within the limits described above. Frequent comparisons with QAD have demonstrated the accuracy and stability of the dilution/GPT audit system.

PARTICULATE SAMPLERS

High Volume Sampler

The high volume sampler was audited using an EPA Reference Device (Figure 3). The device consists of a manometer and a mount with interchangeable orifices and a fixed orifice. Flow rate is measured as a function of the pressure drop across the fixed orifice. The interchangeable orifices are used to vary the flow. The standards used to calibrate the Reference Device are a motor driven positive displacement Roots meter and a water manometer.

Dichotomous Sampler

A dry test meter was used to audit the dichotomous sampler. The meter is traceable to an NBS SRM laminar flow element operated and maintained by QAD.

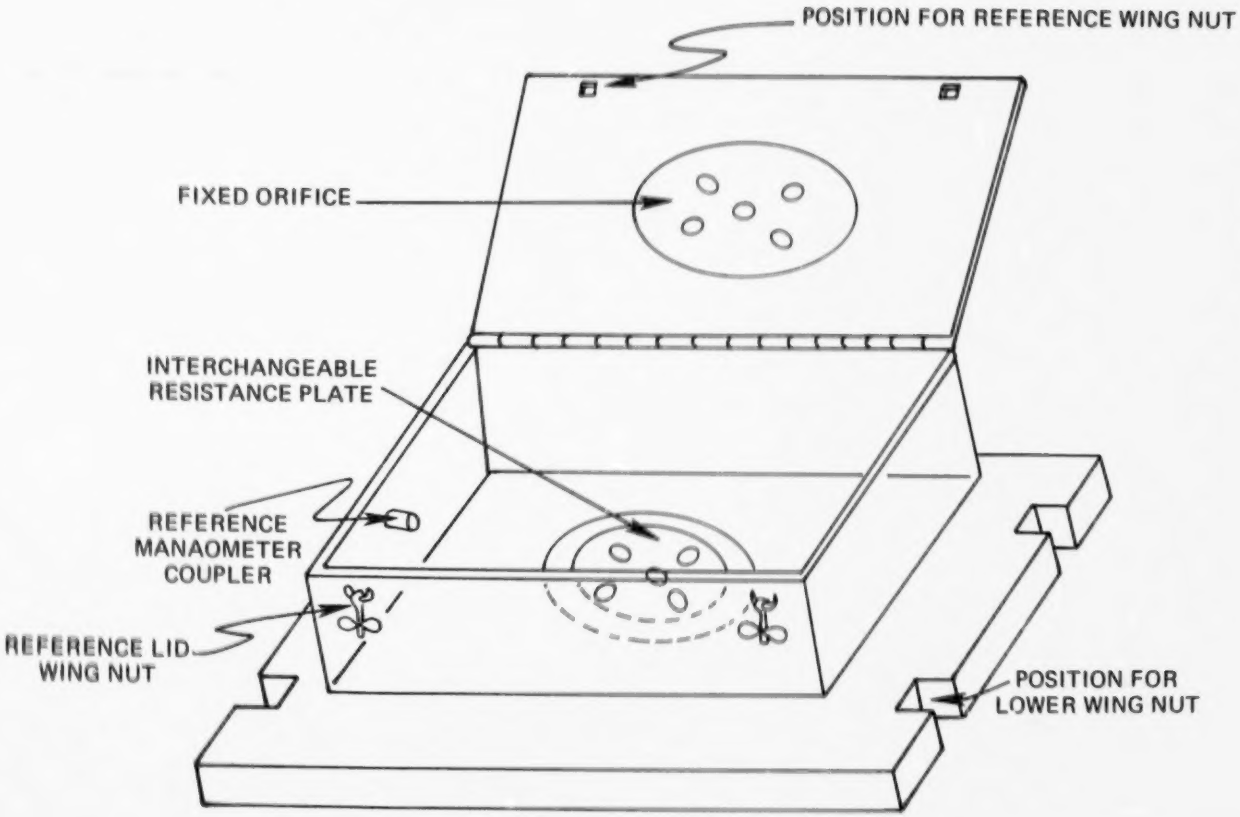
POSITION FOR REFERENCE WING NUT
FIXED ORIFICE
INTERCHANGEABLE RESISTANCE PLATE
REFERENCE MANAOMETER COUPLER
REFERENCE LID WING NUT
POSITION FOR LOWER WING NUT

Figure 3. EPA Reference Device for auditing high volume sampler.

Integrating Nephelometer

The standard used to audit the nephelometer is Freon 12 obtained from a local vendor. Comparisons with other containers from the same and different manufacturers revealed no significant differences measureable with the integrating nephelometer.

METEOROLOGICAL SENSORS

Barometric Pressure

The barometric pressure sensor was audited using a National Semiconductors LX1701A electronic pressure sensor. The standard to which the sensor is traceable is a wall mounted mercury barometer and the local station pressure at Raleigh-Durham Airport.

Dew Point

The dew point sensor was audited using a hand held United States Weather Bureau sling psychrometer.

Temperature

The temperature sensor was audited through reference to the temperature indicated on the dry bulb of the sling psychrometer.

Wind Direction

The wind direction sensor was audited using a system designed by NSI-ES (Figure 4). The system consists of a telescope constructed of nonferrous metal mounted on a leveled platform. A compass is also mounted on the platform, with the bearing indicator aligned parallel to the telescope. A circular reticle (calibrated from 0 to 360°) is mounted in the eyepiece. A mirror is mounted at the base of the tower directly under the wind vane. Wind direction is measured by taking a bearing on the tower and adding the number of degrees indicated on the reticle to the compass bearing. Wind direction is determined by comparison with the known bearing of the cross arm.

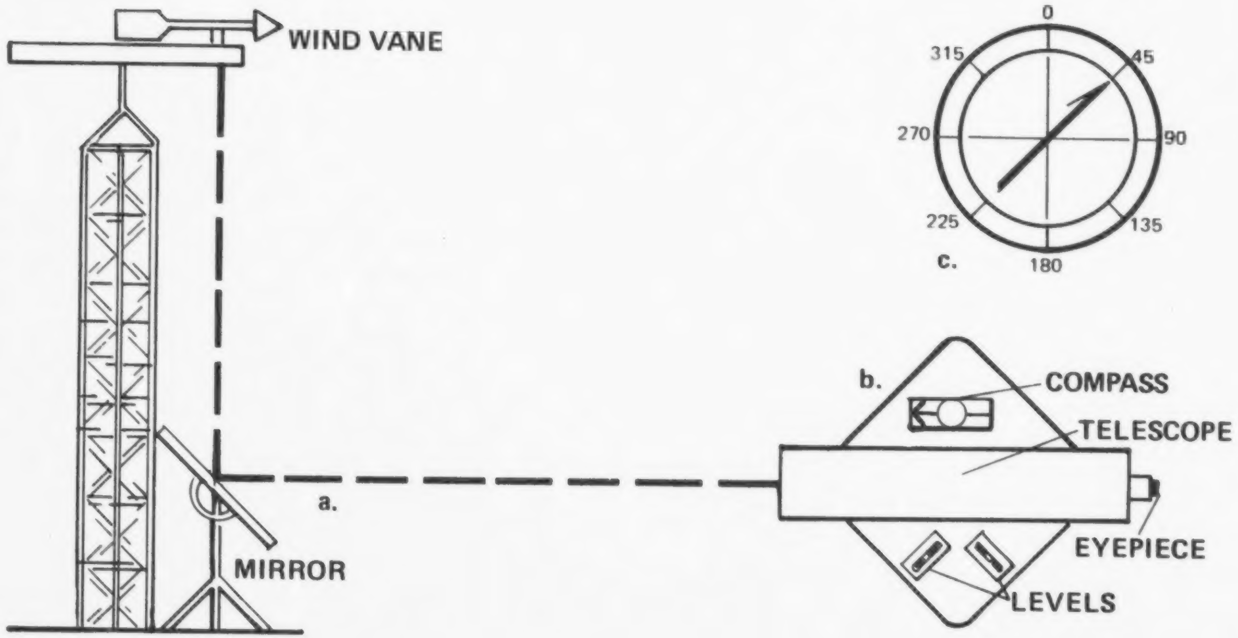
WIND VANE
a.
MIRROR
b.
COMPASS
TELESCOPE
EYEPIECE
LEVELS
c.
0
45
90
135
180
225
270
315

Figure 4. Wind direction audit system.

SECTION 3

CALIBRATION OF AUDIT DEVICES AND STANDARDS

CONTINUOUS ANALYZERS

Oxides of Nitrogen and Total Sulfur

Compressed gas cylinders were used to generate upscale concentrations of total sulfur and nitrogen oxides. These cylinders were held by the manufacturer until three separate analyses (at least one week apart) indicated no degradation. The cylinders were nominally 2.5 ppm in concentration. Following receipt of the cylinders, NSI-ES conducted quarterly analyses of them; traceability to NBS SRM's was maintained in these analyses. Also, cylinder concentration stabilities were confirmed by challenge audit comparisons with QAD before and after each audit.

The mass flow controllers in the dilution/GPT system were calibrated using Hastings bubble meters traceable to NBS SRM burettes. The flow rates of each mass flow controller were measured at five upscale points and at zero flow. The reading from the digital indicator and the set point were recorded. Also, during the audit all flows were measured at the exact set point used.

Ozone

The Dasibi O_3 analyzer modified to operate as a UV photometer was calibrated by the following procedure:

1) Onsite, the instrument was allowed to operate until the cell temperature stabilized. With this particular photometer, the cell temperature typically stabilized at ~35°C.

2) The barometric pressure was determined and used to adjust the span number using the following equation:

$$\text{Span number} = \frac{1000\ \text{counts}}{1\ \text{ppm}} \bullet \frac{10^6\ \text{ppm}}{1\ \text{atm}} \bullet$$

$$\frac{1}{2.3026 \bullet 133.9\ \text{cm}^{-1}\text{atm}^{-1} \bullet 71\ \text{cm}} \bullet \frac{760\ \text{torr}}{P} \bullet \frac{T}{273\ \text{K}}$$

where $133.9\ \text{cm}^{-1}\text{atm}^{-1}$ = absorptivity of O_3 at 254 nm

$71\ \text{cm}^{-1}$ = pathlength

P = ambient pressure torr

T = cell temperature (typically ~300 K)

2.3026 = conversion factor between $\log_{10}$ and $\log_e$

This span number provides 1000 counts/ppm or 1 count/ppb. The calculation can be simplified to the equation

$$\text{Span number } 45682 = \frac{760\ \text{torr}}{P} \bullet \frac{T}{273\ \text{K}}$$

3) The solenoid valve was repeatedly checked for leakage from the zero air to span side and vice versa. These checks were performed before and after each audit trip and (if there was a discrepancy) onsite.

4) The flush and sample cycle times were periodically measured to ensure that at least 5 cell volumes flowed through the cell for each cycle.

5) The photometer was periodically pressurized to ~5 lb/in^2 and the internal fittings checked for leaks using a bubble solution.

DILUTION/GAS PHASE TITRATION AUDIT SYSTEM

The mass flow controllers within the dilution/GPT audit system were calibrated using a Hastings bubble meter traceable to NBS burettes. Each flow rate point was measured 3 times and averaged at 5 points over the range of interest; a calibration curve was constructed. In the field, all flow rates were measured at the exact set point used and corrected to 760 mmHg and 25°C.

PARTICULATE SAMPLERS

High Volume Sampler

Before each audit trip, QAD calibrated the EPA Reference Device (Figure 2) using a positive displacement Roots meter and water manometer. The Roots meter is annually referenced to an NBS primary standard. The Reference Device was calibrated by inserting the 13-hole orifice, varying the flow (hence the pressure drop across the fixed orifice) by varying the revolutions per minute of the Roots meter, and measuring the pressure change indicated. This was done at 5 different flow rates across the normal range for the high volume sampler.

The procedure was repeated 3 times and the linear regression of best fit and confidence intervals calculated.

Dichotomous Sampler

The Singer dry test meter used to audit the dichotomous sampler flow rates was calibrated by QAD using an NBS laminar flow element. At each measurement point, 3 repetitions of 5 rotations of the meter were made and linear regression and confidence intervals calculated.

METEOROLOGICAL SENSORS

Barometric Pressure

The electronic barometer used to audit the barometric pressure sensor was calibrated through reference to a mercury barometer and to the Raleigh-Durham Airport local station pressure. Calibration was performed before and after each audit trip.

Temperature and Dew Point

The thermometers of the sling psychrometer were calibrated through reference to a certified thermometer.

Wind Direction

Wind direction was measured by a compass indicating magnetic North.

SECTION 4

VERIFICATION OF AUDIT DEVICES, STANDARDS, AND OPERATOR TECHNIQUES

To verify that the audit equipment, pollutant standards, flowmeters, and operator techniques were correct, NSI-ES performed comparison audits in the QAD verification lab before each audit trip. This comparison was performed for O_3, NO, NO_2, and SO_2. Equipment was handled exactly as in the field: it was unloaded from the vehicle, assembled in the QAD lab, turned on, allowed to warm up, and then used for the comparison audit. The same equipment was then transported to the station sites and used to perform the audits.

RESULTS OF QAD AUDIT CERTIFICATION COMPARISONS

Results of the QAD audit verification comparisons conducted before each audit trip are summarized in Tables 1 through 4 (O_3, NO, NO_2, and SO_2, respectively). Variable #1 is the QAD analysis of the NSI-ES generated audit concentration. Variable #2 is the NSI-ES calculated value of the generated audit concentration. Variable #3 is the difference (in parts per billion) between Variable #2 and Variable #1. Below the data lists are the "Basic Statistics" for Variable #3.

Following each table is a plot of the estimated line of best fit and its confidence intervals (Figures 5 through 8). The values for slope and intercept are given. These plots are obtained using the "Bartlett Method" computer program authored by M. V. Smith, R. W. Shaw, Jr. and R. J. Paur of the Environmental Sciences Research Laboratory (EPA-ORD-RTP).

These tables and plots summarize the results of four separate certification audits conducted in the QAD facility; they serve as a standard of comparison in evaluating the results of the ORV station audits.

Appendix A presents QAD's official statements of the audit certification comparison results.

TABLE 1. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR OZONE

```
             Variable # 1    Variable # 2    Variable # 3
    OBS#
       1
             184.00000       185.00000        -1.00000
       2
              91.00000        88.00000         3.00000
       3
              38.00000        37.00000         1.00000
       4
              18.00000        14.00000         4.00000
       5
               0.00000         0.00000         0.00000
       6
             178.00000       177.00000         1.00000
       7
              83.00000        80.00000         3.00000
       8
              47.00000        46.00000         1.00000
       9
              17.00000        14.00000         3.00000
      10
             158.00000       158.00000         0.00000
      11
             106.00000       109.00000        -3.00000
      12
              54.00000        56.00000        -2.00000
      13
              10.00000         9.00000         1.00000
      14
               0.00000         0.00000         0.00000
      15
               0.00000         0.00000         0.00000


                             BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES            SUM          MEAN
DIF(ppb)                 15                0       11.00000        .73333
-------------------------------------------------------------------------
                                                    COEF OF       COEF OF
VARIABLE           VARIANCE   STANDARD DEV.        SKEWNESS      KURTOSIS
DIF(ppb)            3.78095         1.94447         -.09422       -.57304
-------------------------------------------------------------------------
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN     LOWER LIMIT    UPPER LIMIT
DIF(ppb)          265.15461          .50206         -.34375       1.81041
-------------------------------------------------------------------------

                             ORDER STATISTICS


VARIABLE            MAXIMUM         MINIMUM           RANGE      MIDRANGE
DIF(ppb)            4.00000        -3.00000         7.00000        .50000
-------------------------------------------------------------------------
```

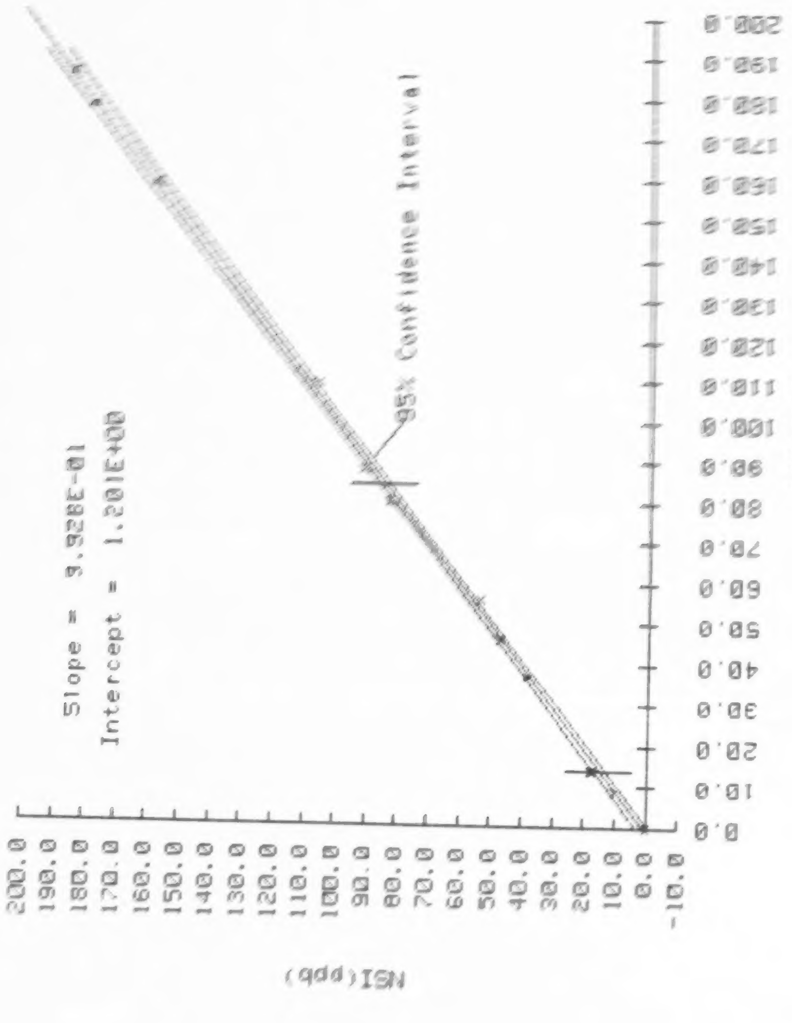

Figure 5. Estimated line of best fit: QAD audit certification comparisons for ozone.

TABLE 2. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR NITRIC OXIDE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
  1
          54.00000       54.00000        0.00000
  2
          55.00000       53.00000        2.00000
  3
          11.00000       10.00000        1.00000
  4
           7.00000        6.00000        1.00000
  5
           8.00000        8.00000        0.00000
  6
          93.00000       92.00000        1.00000
  7
          58.00000       57.00000        1.00000
  8
          11.00000       10.00000        1.00000
  9
           7.00000        5.00000        2.00000
 10
           8.00000        8.00000        0.00000
 11
          93.00000       91.00000        2.00000
 12
          61.00000       60.00000        1.00000
 13
          11.00000       10.00000        1.00000
 14
           5.00000        5.00000        0.00000
 15
           0.00000        0.00000        0.00000
```

```
                                BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES            SUM              MEAN



DIF(ppb)                 15                0       13.00000            .86667
---------------------------------------------------------------------------------
                                                    COEF OF           COEF OF
VARIABLE           VARIANCE    STANDARD DEV.       SKEWNESS          KURTOSIS
DIF(ppb)             .55238           .74322         .20330          -1.05054
---------------------------------------------------------------------------------
                                STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION       OF THE MEAN     LOWER LIMIT       UPPER LIMIT
DIF(ppb)           85.75654            .19190          .45498           1.27835
---------------------------------------------------------------------------------

                                ORDER STATISTICS


VARIABLE            MAXIMUM          MINIMUM          RANGE          MIDRANGE
DIF(ppb)            2.00000          0.00000        2.00000           1.00000
=================================================================================
```

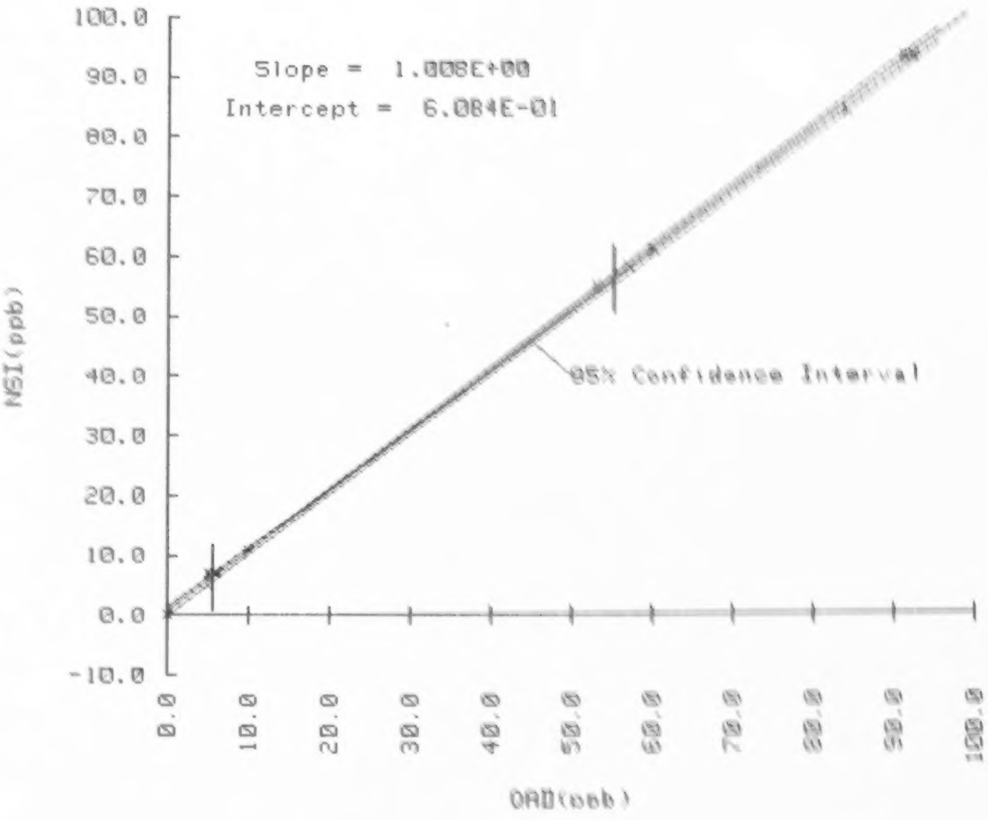

Figure 6. Estimated line of best fit: QAD audit certification comparisons for nitric oxide.

TABLE 3. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR NITROGEN DIOXIDE

```
          Variable # 1    Variable # 2    Variable # 3
   OBS#
     1
              61.00000        63.00000        -2.00000
     2
              53.00000        55.00000        -2.00000
     3
              13.00000        15.00000        -2.00000
     4
               4.00000         4.00000         0.00000
     5
               0.00000         0.00000         0.00000
     6
              86.00000        85.00000         1.00000
     7
              62.00000        60.00000         2.00000
     8
              19.00000        15.00000         4.00000
     9
               7.00000         3.00000         4.00000
    10
               0.00000         0.00000         0.00000
    11
              76.00000        74.00000         2.00000
    12
              32.00000        31.00000         1.00000
    13
              16.00000        15.00000         1.00000
    14
               6.00000         5.00000         1.00000
    15
               0.00000         0.00000         0.00000



                              BASIC STATISTICS

VARIABLE     # OBSERVATIONS    # MISS. VALUES
DIF(ppb)                 15                 0           SUM            MEAN
                                                   10.00000          .66667
---------------------------------------------------------------------------
VARIABLE           VARIANCE    STANDARD DEV.        COEF OF         COEF OF
DIF(ppb)            3.52381          1.87718       SKEWNESS        KURTOSIS
                                                     .23348         -.49909
---------------------------------------------------------------------------
                                STANDARD ERROR
VARIABLE     COEF VARIATION        OF THE MEAN   95 % CONFIDENCE INTERVAL ON MEAN
DIF(ppb)          281.57719             .48469      LOWER LIMIT     UPPER LIMIT
                                                       -.37314         1.70648
---------------------------------------------------------------------------

                              ORDER STATISTICS


VARIABLE
DIF(ppb)            MAXIMUM          MINIMUM          RANGE        MIDRANGE
                    4.00000         -2.00000        6.00000         1.00000
---------------------------------------------------------------------------
```

TYPING GUIDE SHEET

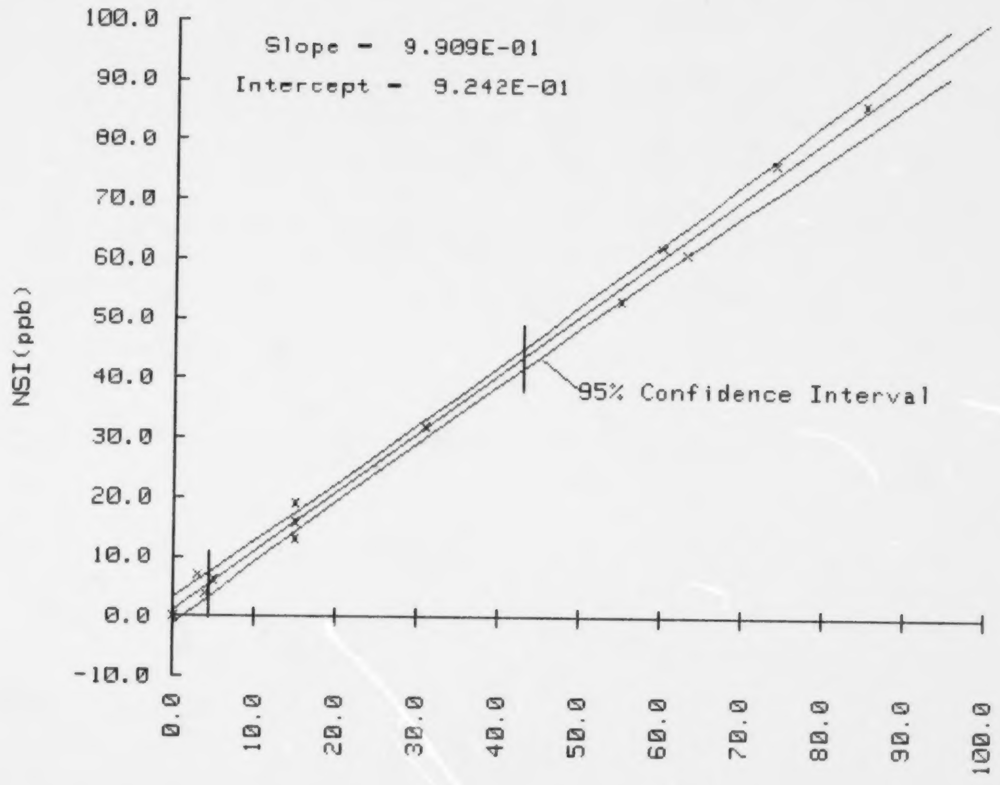

Figure 7. Estimated line of best fit: QAD audit certification comparisons for nitrogen dioxide.

EPA Form 2350-4 (4-80)
TYPING GUIDE SHEET

TABLE 4. SUMMARY: QAD AUDIT CERTIFICATION COMPARISONS FOR SULFUR DIOXIDE

```
         Variable # 1   Variable # 2   Variable # 3
OBS#
  1
           87.00000       87.00000       0.00000
  2
           61.00000       64.00000      -3.00000
  3
            8.00000        7.00000       1.00000
  4
            5.00000        4.00000       1.00000
  5
            0.00000        0.00000       0.00000
  6
           86.00000       82.00000       4.00000
  7
           36.00000       35.00000       1.00000
  8
            7.00000        7.00000       0.00000
  9
            0.00000        0.00000       0.00000
 10
           88.00000       87.00000       1.00000
 11
           43.00000       41.00000       2.00000
 12
            8.00000        8.00000       0.00000
 13
            5.00000        5.00000       0.00000
 14
            0.00000        0.00000       0.00000
```

```
                               BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES            SUM             MEAN
DIF(ppb)                  14                0        7.00000           .50000
-------------------------------------------------------------------------------
VARIABLE            VARIANCE   STANDARD DEV.         COEF OF          COEF OF
DIF(ppb)             2.26923         1.50640        SKEWNESS         KURTOSIS
                                                      .07006          1.92071
-------------------------------------------------------------------------------
VARIABLE      COEF VARIATION  STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
                               OF THE MEAN       LOWER LIMIT      UPPER LIMIT


DIF(ppb)           301.27932          .40260        -.36999          1.36999
---------------------------------  ------------------------------------------

                               ORDER STATISTICS

VARIABLE             MAXIMUM         MINIMUM           RANGE         MIDRANGE
DIF(ppb)             4.00000        -3.00000         7.00000           .50000
-------------------------------------------------------------------------------
```

BEGIN FIRST LINE OF TEXT HERE
CENTER OF
TOP OF IMAGE AREA
DROPPED HEAD; BEGIN SECTIONS HERE
BEGIN LAST LINE OF TEXT
3/16"
BOTTOM OF IMAGE AREA OUTSIDE DIMENSION FOR TABLES AND ILLUSTRATIONS
EPA Form 2350-1 (4-80)
(PREVIOUSLY CIN. EPA FORM 231)
TYPING GUIDE SHEET

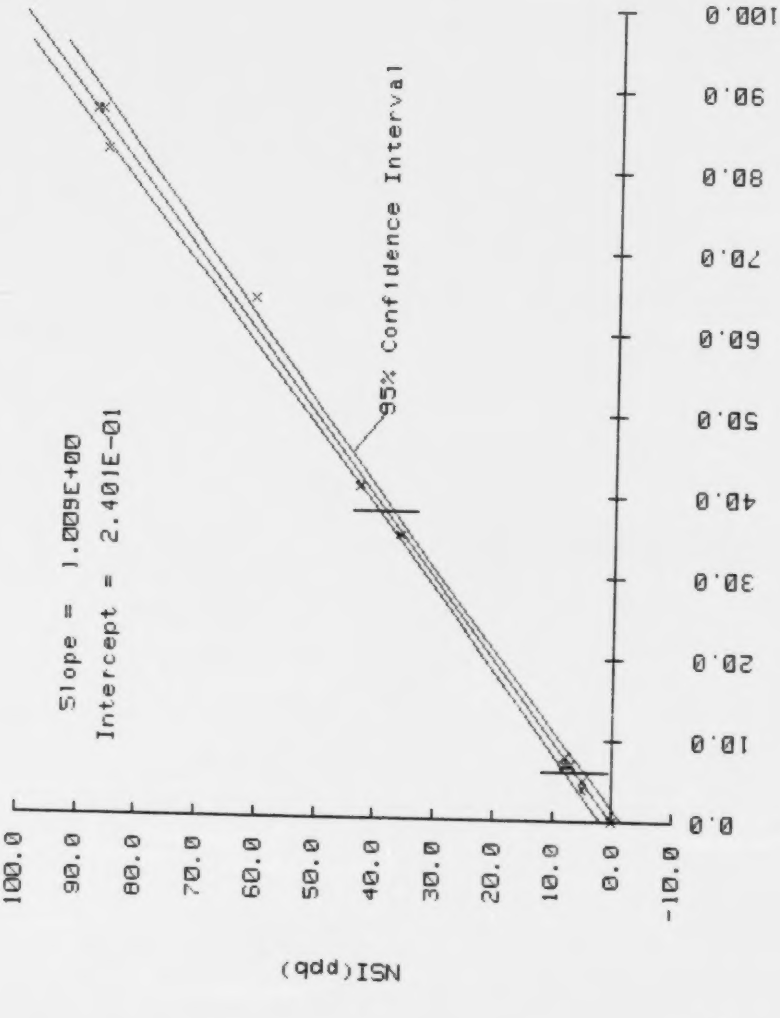

Figure 8. Estimated line of best fit: QAD audit certification comparisons for sulfur dioxide.

SECTION 5

CRITERIA OF ACCEPTABLE PERFORMANCE

The criteria for acceptable performance presented below are offered as a basis for discussion and not as a judgment of the validity of the data collected by MTL.

CONTINUOUS ANALYZERS

Criteria for the gaseous analyzers were based on the QAD audit certification comparisons conducted before and after each audit. The standard deviation of the difference (expressed in parts per billion) calculated for each NSI-ES/QAD comparison was used as a standard.

Similarly for the NSI-ES/MTL comparisons, the standard deviation of the difference (expressed in parts per billion) was calculated for each analyzer. A grade was determined using the equation

$$\text{grade} = 100 - \left[5 \left(\frac{\text{MTL} - \text{NSI}}{\text{NSI}} \right) + 20 \left(\frac{\sum_{i=1}^{N} \left| \frac{X_i - Y_i}{Y_i} \right|}{N} - \frac{\sum_{i=1}^{M} \left| \frac{B_i - Q_i}{Q_i} \right|}{M} \right) \right]$$

where NSI = standard deviation of the difference (ppb) of the NSI-ES/QAD comparisons

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MTL = standard deviation of the difference (ppb) of the NSI-ES/MTL comparisons

X_i = instrument response

Y_i = calculated audit concentration

N = number of audit points

B_i = Northrop's calculated concentration during certification

Q_i = QAD's instrument response

M = number of audit certification points

Thus, if an NSI-ES/MTL comparison yields a standard deviation that is 3 times the standard deviation of the corresponding NSI-ES/QAD comparison, the grade is 80. A grade of <70 indicates unacceptable performance.

PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

For the particulate samplers and meteorological sensors, station grades were determined using an equation that is based on the percent difference only, since the measurements involved were (for the most part) single point measurements and because comparison audits to evaluate operator technique and calibration standards were not performed. The devices used to audit these sensors are, however, calibrated periodically. For the temperature, dewpoint, and wind direction sensors, the absolute value of the differences between station sensors and audit sensors were summed and the mean value calculated. Grades were not calculated for these sensors.

Station grades were calculated by the equation:

$$\text{grade} = 100 - 200 \left(\frac{\sum_{i=1}^{N} \left| \frac{X_i - Y_i}{Y_i} \right|}{N} \right)$$

where X_i = instrument response

Y_i = calculated audit response

N = number of audit points

Thus a sensor whose mean percent difference was 10% would receive a grade of 80. A difference of >15% yields of grade of <70, indicating unacceptable performance.

SECTION 6

SUMMARY OF AUDIT RESULTS

Appendix B presents the individual results of the November, January, and March audits.

CONTINUOUS ANALYZERS

Tables 5 through 19 summarize the results of the 3 audits of gaseous analyzers. Data are listed in the chronological order in which they were obtained. Variable #1 is the NSI-ES audit concentration; Variable #2 is the MTL analyzer response; and Variable #3 the difference (in parts per billion) between Variable #2 and Variable #1. Below each data list are the "Basic Statistics" for Variable #3.

Following each table is a plot of the estimated line of best fit and its confidence intervals (Figures 9 through 23). These plots were obtained in the same manner as those presented in Section 4.

Table 20 displays the grades calculated for each pollutant at each station.

PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

The results of the particulate and meteorological sampling system audits are summarized in Table 21. Grades were calculated as described in Section 5 and are offered here for purposes of discussion and not as a measure of the validity of data collected by the ORV stations.

TABLE 5: SUMMARY: AUDIT OF UNION COUNTY STATION FOR OZONE

OBS#	VARIABLE # 1	VARIABLE # 2	VARIABLE # 3
1	168.00000	167.00000	-1.00000
2	64.00000	64.00000	0.00000
3	37.00000	37.00000	0.00000
4	22.00000	23.00000	1.00000
5	4.20000	4.40000	.20000
6	0.00000	-.30000	-.30000
7	153.00000	143.00000	-10.00000
8	57.00000	54.00000	-3.00000
9	20.00000	19.00000	-1.00000
10	11.00000	12.00000	1.00000
11	0.00000	0.00000	0.00000
12	178.00000	171.00000	[illegible]
13	74.00000	[illegible]	[illegible]
14	[illegible]	[illegible]	0.00000
15	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]

[illegible]

[illegible]

ORDER STATISTICS

VARIABLE	MAXIMUM	MINIMUM	RANGE	MIDRANGE
DIF[illegible]	1.00000	-10.00000	11.00000	-4.50000

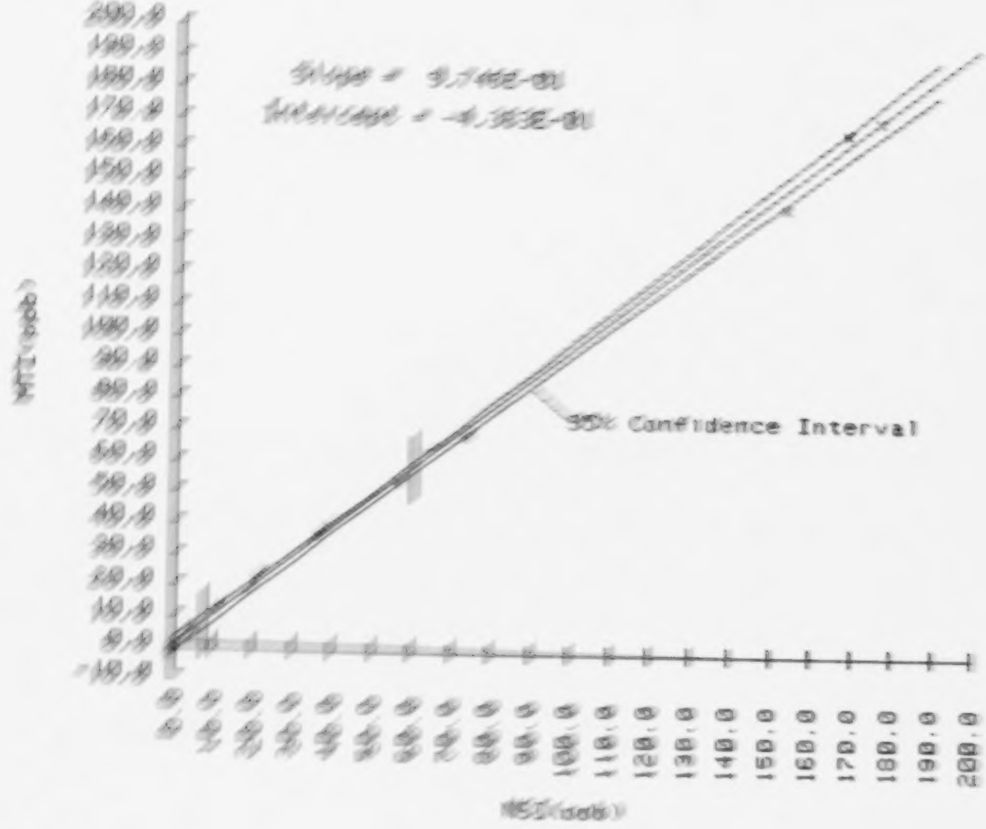

Figure 9, Estimated line of best fit; audit of Union County station for ozone.

TABLE 6. SUMMARY: AUDIT OF MORGANFIELD STATION FOR NITRIC OXIDE

OBS#	Variable # 1	Variable # 2	Variable # 3
1	89.00000	90.00000	1.00000
2	55.00000	55.00000	0.00000
3	11.00000	12.00000	1.00000
4	7.00000	7.00000	0.00000
5	0.00000	1.00000	1.00000
6	85.00000	87.00000	2.00000
7	53.00000	54.00000	1.00000
8	11.00000	10.00000	-1.00000
9	7.00000	7.00000	0.00000
10	0.00000	0.00000	0.00000
11	93.00000	96.00000	3.00000
12	51.00000	53.00000	2.00000
13	10.00000	10.00000	0.00000
14	11.00000	11.00000	0.00000
15	0.00000	0.00000	0.00000

[illegible]

ORDER STATISTICS

VARIABLE	MAXIMUM	MINIMUM	RANGE	MIDRANGE
DIFF,ppb	3.00000	-1.00000	4.00000	1.00000

NSI NTL COMPARISON, UNION COUNTY,KY 801117-810319 NO

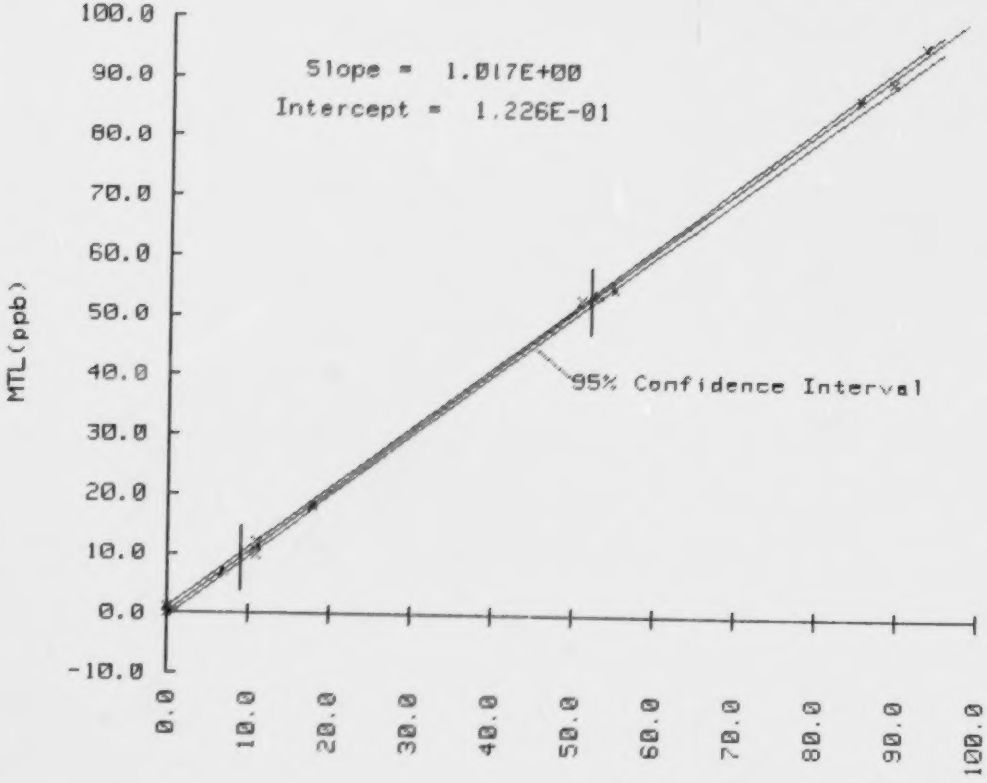

Figure 10. Estimated line of best fit: Audit of Union County station for nitric oxide.

TABLE 7. SUMMARY: AUDIT OF UNION COUNTY STATION FOR NITROGEN DIOXIDE

```
        Variable # 1    Variable # 2   Variable # 3
 OBS#
    1
           87.00000       81.00000      -6.00000
    2
           58.00000       53.00000      -5.00000
    3
           17.00000       11.00000      -6.00000
    4
            5.00000        -.20000      -5.20000
    5
            0.00000        2.00000       2.00000
    6
           56.00000       52.00000      -4.00000
    7
           53.00000       49.00000      -4.00000
    8
           17.00000       13.00000      -4.00000
    9
            9.00000        4.00000      -5.00000
   10
            0.00000        1.00000       1.00000
   11
           82.00000       78.00000      -4.00000
   12
           64.00000       60.00000      -4.00000
   13
           30.00000       26.00000      -4.00000
   14
           19.00000       16.00000      -3.00000
   15
            0.00000        0.00000       0.00000
```

```
                               BASIC STATISTICS
______________________________________________________________________

VARIABLE     # OBSERVATIONS   # MISS. VALUES            SUM          MEAN
DIF(ppb)                 15                0      -51.20000      -3.41333
=========================================================================
                                                    COEF OF       COEF OF
VARIABLE           VARIANCE   STANDARD DEV.        SKEWNESS      KURTOSIS
DIF(ppb)            6.01981         2.45353         1.17595        .14035
=========================================================================
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)           71.88076          .63350        -4.77239        -2.05427
=========================================================================


                               ORDER STATISTICS
______________________________________________________________________


VARIABLE            MAXIMUM         MINIMUM           RANGE      MIDRANGE
DIF(ppb)            2.00000        -6.00000         8.00000      -2.00000
=========================================================================
```

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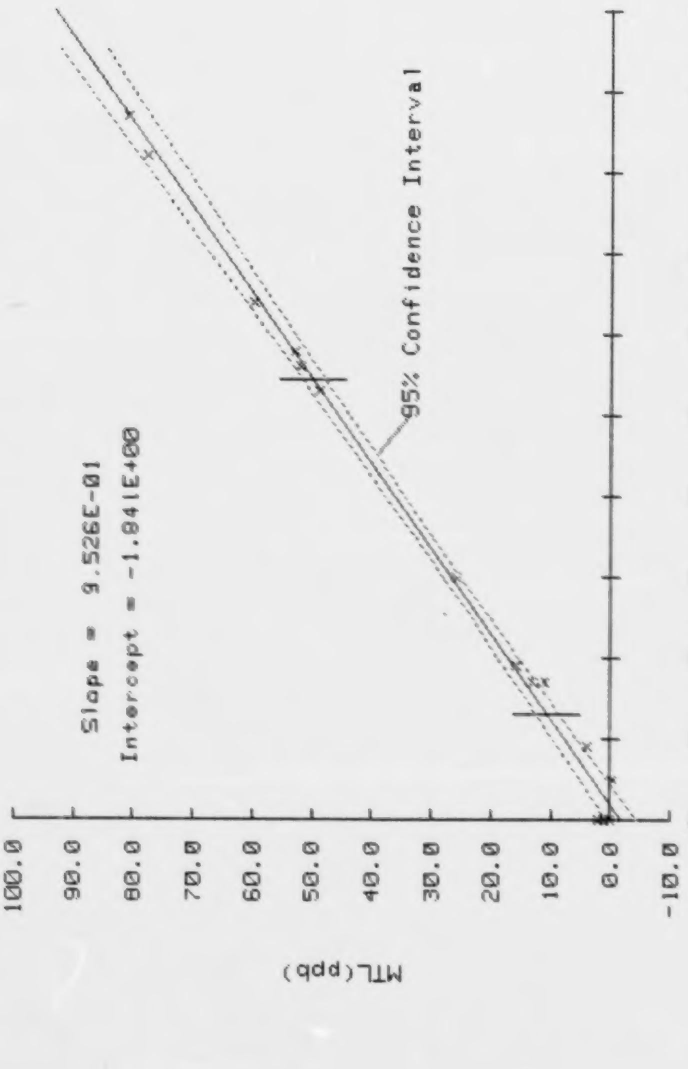

Figure 11. Estimated line of best fit: Audit of Union County station for nitrogen dioxide.

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TABLE 8. SUMMARY: AUDIT OF UNION COUNTY STATION FOR TOTAI NITROGEN OXIDES

```
           Variable # 1   Variable # 2   Variable # 3
OBS#
   1
            84.00000       83.00000       -1.00000
   2
            52.00000       50.00000       -2.00000
   3
            11.00000        5.00000       -6.00000
   4
             0.00000       -4.00000       -4.00000
   5
            95.00000       93.00000       -2.00000
   6
            59.00000       54.00000       -5.00000
   7
            12.00000        9.00000       -3.00000
   8
             8.00000        5.00000       -3.00000
   9
             0.00000       -2.00000       -2.00000
  10
            93.00000       95.00000        2.00000
  11
            49.00000       50.00000        1.00000
  12
            15.00000       16.00000        1.00000
  13
             8.00000        7.00000       -1.00000
  14
             0.00000        0.00000        0.00000
```

```
                              BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES                 SUM          MEAN
DIF(ppb)                  14                0           -25.00000      -1.78571
---------------------------------------------------------------------------------
                                                          COEF OF       COEF OF
VARIABLE            VARIANCE    STANDARD DEV.           SKEWNESS      KURTOSIS
DIF(ppb)             5.41209          2.32639            -.11645       -.77327
---------------------------------------------------------------------------------


                                STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION      OF THE MEAN         LOWER LIMIT     UPPER LIMIT
DIF(ppb)           130.27781           .62175          -3.12927        -.44216
---------------------------------------------------------------------------------

                              ORDER STATISTICS

VARIABLE             MAXIMUM          MINIMUM            RANGE         MIDRANGE
DIF(ppb)             2.00000         -6.00000          8.00000        -2.00000
---------------------------------------------------------------------------------
```

TYPING GUIDE SHEET

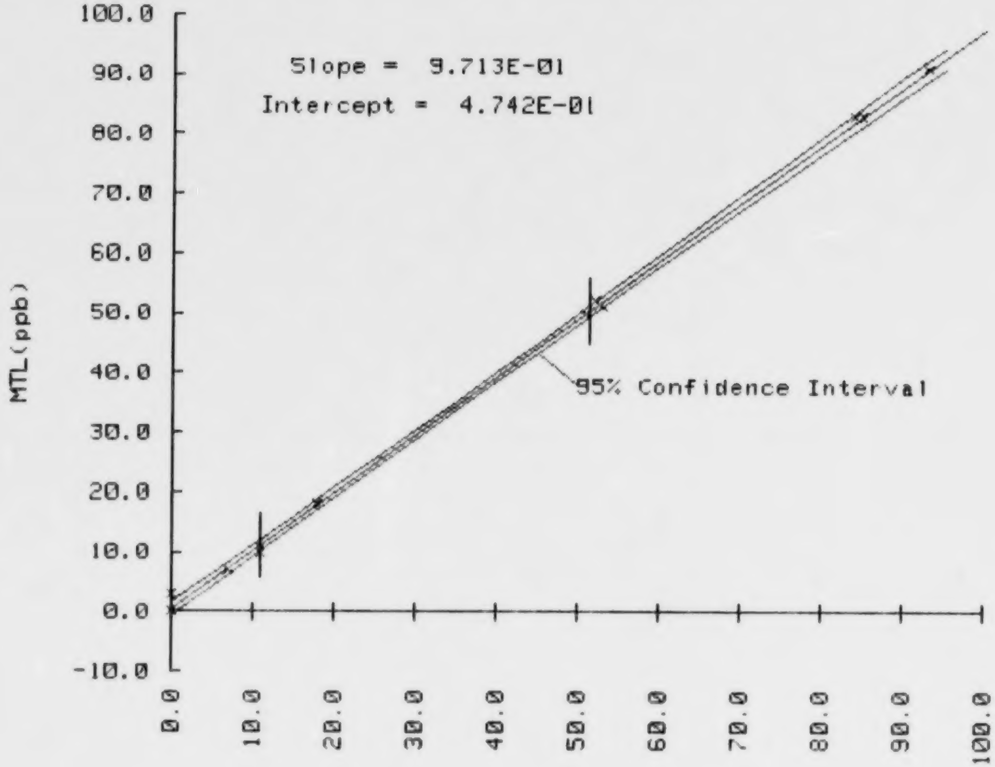

Figure 12. Estimated line of best fit: Audit of Union County station for total nitrogen oxides.

TABLE 9. SUMMARY: AUDIT OF UNION COUNTY STATION FOR SULFUR DIOXIDE

```
           Variable # 1    Variable # 2    Variable # 3
    OBS#
      1
             84.00000        92.00000         8.00000
      2
             39.00000        41.00000         2.00000
      3
              8.00000         3.00000        -5.00000
      4
              5.00000         2.00000        -3.00000
      5
              0.00000         0.00000         0.00000
      6
             92.00000       104.00000        12.00000
      7
             58.00000        62.00000         4.00000
      8
             11.00000         3.00000        -8.00000
      9
              7.00000         1.00000        -6.00000
     10
              0.00000         0.00000         0.00000


                          BASIC STATISTICS

VARIABLE    # OBSERVATIONS   # MISS. VALUES            SUM           MEAN
DIF(ppb)                10                0        4.00000         .40000
-------------------------------------------------------------------------



                                                   COEF OF        COEF OF
VARIABLE          VARIANCE    STANDARD DEV.       SKEWNESS       KURTOSIS
DIF(ppb)          40.04444          6.32807         .46167        -.74748
-------------------------------------------------------------------------
                            STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE    COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)        1582.01700         2.00111        -4.12803         4.92803
-------------------------------------------------------------------------

                          ORDER STATISTICS

VARIABLE           MAXIMUM          MINIMUM          RANGE       MIDRANGE
DIF(ppb)          12.00000         -8.00000       20.00000        2.00000
-------------------------------------------------------------------------
```

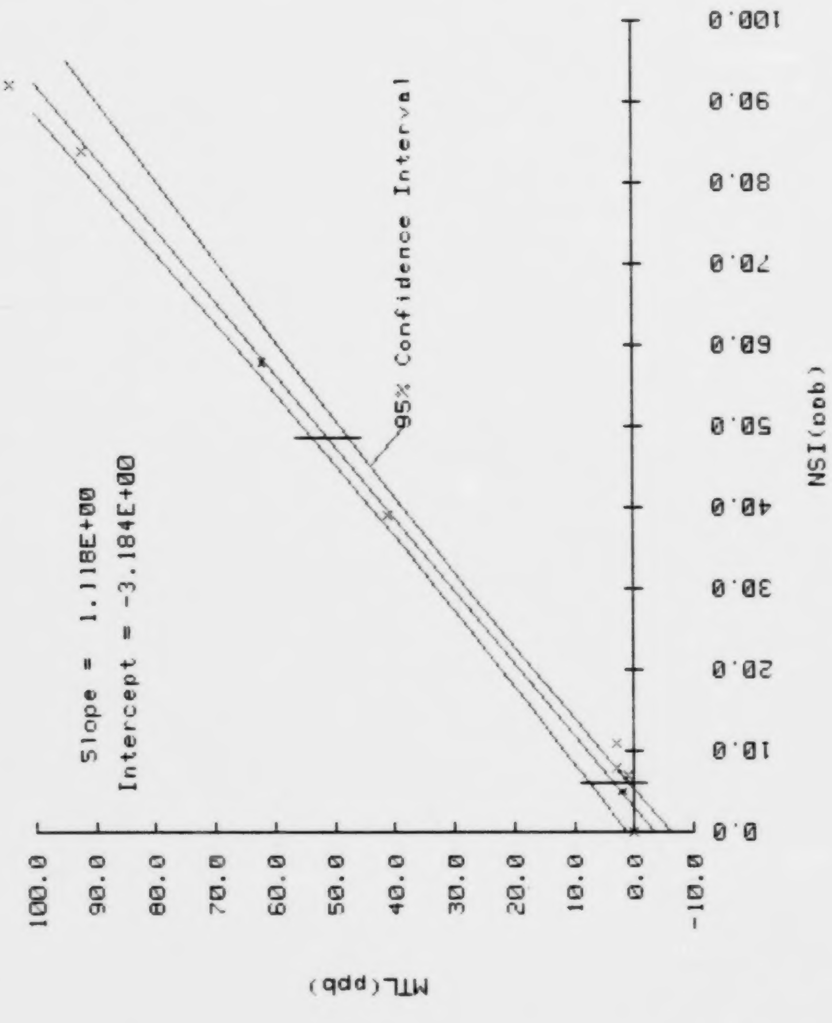

Figure 13. Estimated line of best fit: Audit of Union County station for sulfur dioxide.

TYPING GUIDE SHEET

TABLE 10. SUMMARY: AUDIT OF FRANKLIN COUNTY STATION FOR OZONE

```
         Variable # 1    Variable # 2   Variable # 3
OBS#
   1
           180.00000       187.00000        7.00000
   2
            68.00000        70.00000        2.00000
   3
            26.00000        28.00000        2.00000
   4
             0.00000         0.00000        0.00000
   5
           120.00000       116.00000       -4.00000
   6
            53.00000        51.00000       -2.00000
   7
            16.00000        18.00000        2.00000
   8
             8.00000        10.00000        2.00000
   9
             0.00000         0.00000        0.00000


                              BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES            SUM            MEAN
DIF(ppb)                  9                0        9.00000         1.00000
---------------------------------------------------------------------------
                                                    COEF OF         COEF OF
VARIABLE           VARIANCE   STANDARD DEV.        SKEWNESS        KURTOSIS
DIF(ppb)            9.50000         3.08221          .29884          .12881
---------------------------------------------------------------------------
                             STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)          308.22070         1.02740        -1.36983         3.36983
---------------------------------------------------------------------------

                              ORDER STATISTICS

VARIABLE            MAXIMUM         MINIMUM           RANGE        MIDRANGE
DIF(ppb)            7.00000        -4.00000        11.00000         1.50000
---------------------------------------------------------------------------
```

TYPING GUIDE SHEET

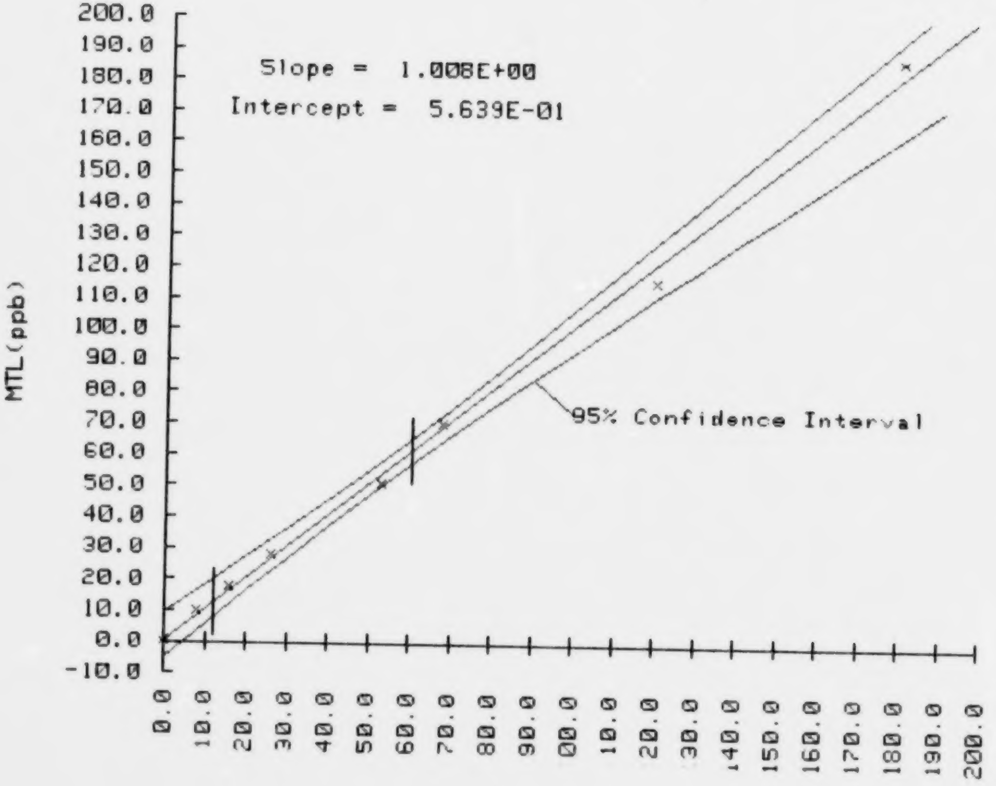

Figure 14. Estimated line of best fit: Audit of Franklin County station for ozone.

TABLE 11. SUMMARY: AUDIT OF FRANKLIN COUNTY STATION FOR NITRIC OXIDE

```
        Variable # 1    Variable # 2    Variable # 3
  OBS#
    1
           83.00000        78.00000        -5.00000
    2
           39.00000        35.00000        -4.00000
    3
            7.00000         6.00000        -1.00000
    4
            0.00000         -.50000         -.50000
    5
           88.00000        82.00000        -6.00000
    6
           11.00000         9.00000        -2.00000
    7
            5.00000         5.00000         0.00000
    8
            0.00000        -1.00000        -1.00000
    9
           93.00000        93.00000         0.00000
   10
           49.00000        49.00000         0.00000
   11
           15.00000        15.00000         0.00000
   12
            8.00000         6.00000        -2.00000
   13
            0.00000         0.00000         0.00000


                            BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES
DIF(ppb)                  13                0            SUM             MEAN
                                                   -21.50000         -1.65385
------------------------------------------------------------------------------
VARIABLE                                                COEF OF
DIF(ppb)            VARIANCE   STANDARD DEV.           SKEWNESS         COEF OF
                     4.30769         2.07550           -1.04624        KURTOSIS
                                                                        -.31429
------------------------------------------------------------------------------
                               STANDARD ERROR
VARIABLE      COEF VARIATION     OF THE MEAN   95 % CONFIDENCE INTERVAL ON MEAN
DIF(ppb)           125.49523          .57564       LOWER LIMIT      UPPER LIMIT
                                                     -2.90838          -.39931
------------------------------------------------------------------------------

                            ORDER STATISTICS


VARIABLE
DIF(ppb)             MAXIMUM         MINIMUM
                     0.00000        -6.00000          RANGE        MIDRANGE
                                                     6.00000        -3.00000
------------------------------------------------------------------------------
```

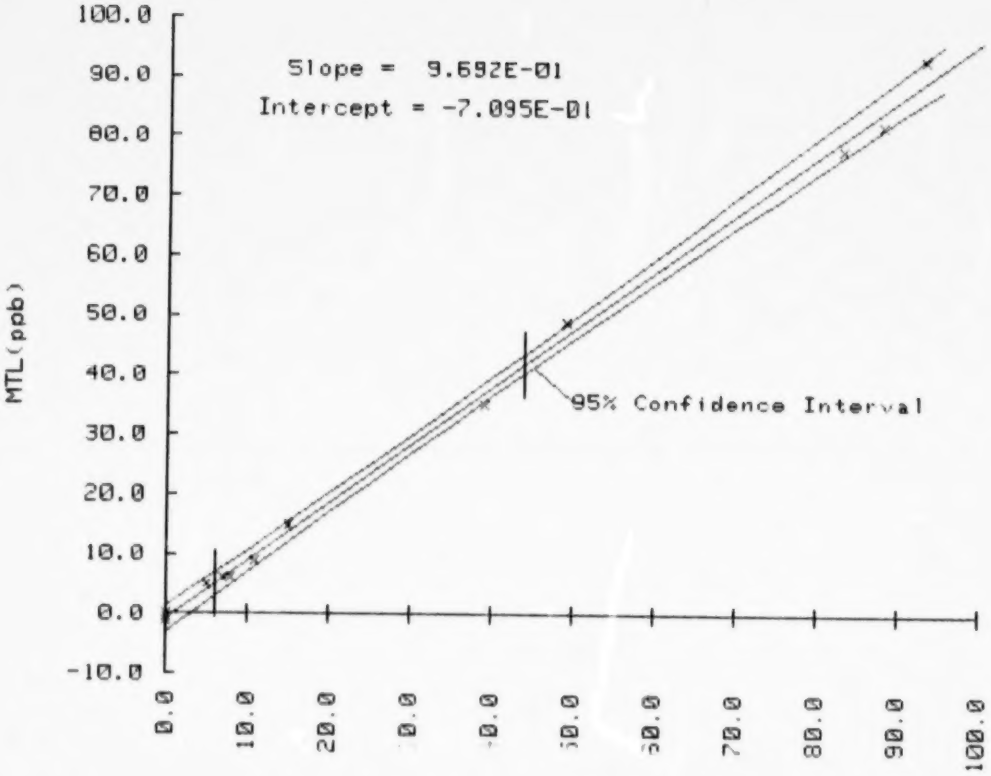

Figure 15. Estimated line of best fit: Audit of Franklin County station for nitric oxide.

TABLE 12. SUMMARY: AUDIT OF FRANKLIN COUNTY STATION FOR NITROGEN DIOXIDE

```
         Variable # 1       Variable # 2    Variable # 3
OBS#
   1
          77.00000          79.00000          2.00000
   2
          45.00000          46.00000          1.00000
   3
           0.00000           1.00000          1.00000
   4
          54.00000          50.00000         -4.00000
   5
          11.00000          12.00000          1.00000
   6
           3.00000           5.00000          2.00000
   7
           0.00000           1.00000          1.00000
   8
          82.00000          80.00000         -2.00000
   9
          42.00000          40.00000         -2.00000
  10
          19.00000          19.00000          0.00000
  11
           5.00000           4.00000         -1.00000
  12
           0.00000           0.00000          0.00000


                          BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES           SUM            MEAN



DIF(ppb)                  12                0      -1.00000         -.08333
-------------------------------------------------------------------------------
                                                    COEF OF         COEF OF
VARIABLE            VARIANCE    STANDARD DEV.      SKEWNESS        KURTOSIS
DIF(ppb)             3.35606          1.83196       -.79944         -.30381
-------------------------------------------------------------------------------
                               STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION      OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)          2198.34649           .52884      -1.24760         1.08094
-------------------------------------------------------------------------------

                          ORDER STATISTICS


VARIABLE             MAXIMUM          MINIMUM         RANGE        MIDRANGE
DIF(ppb)             2.00000         -4.00000       6.00000        -1.00000
-------------------------------------------------------------------------------
```

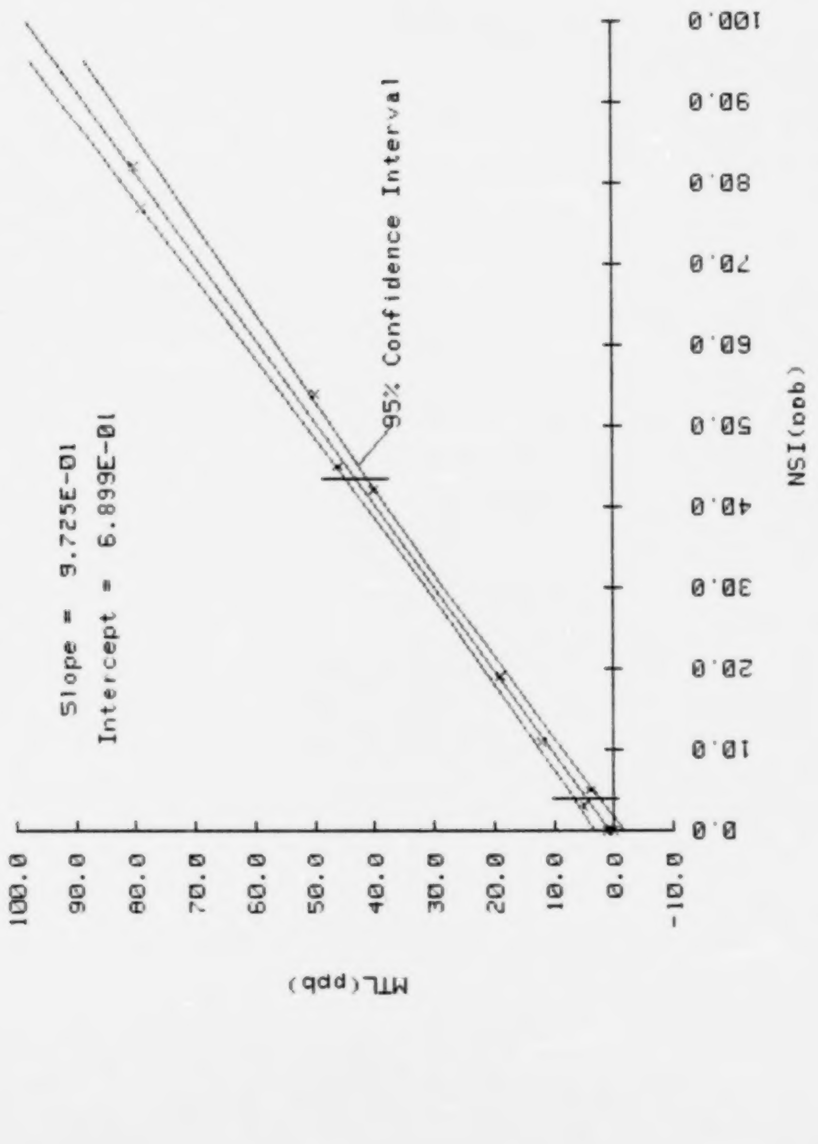

Figure 16. Estimated line of best fit: Audit of Franklin County station for nitrogen dioxide.

TABLE 13. SUMMARY: AUDIT OF FRANKLIN COUNTY STATION FOR TOTAL NITROGEN OXIDES

```
          Variable # 1    Variable # 2    Variable # 3
OBS#
   1
            83.00000        76.00000        -5.00000
   2
            39.00000        35.00000        -4.00000
   3
             7.00000         6.00000        -1.00000
   4
             0.00000         -.50000         -.50000
   5
            88.00000        81.00000        -7.00000
   6
            11.00000         9.00000        -2.00000
   7
             5.00000         7.60000         2.00000
   8
             0.00000         3.00000         3.00000
   9
            93.00000        96.00000         3.00000
  10
            49.00000        50.00000         1.00000
  11
            15.00000        15.00000         0.00000
  12
             8.00000         8.00000         0.00000
  13
             0.00000         0.00000         0.00000
```

```
                                BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES             SUM           MEAN
DIF(ppb)                 13                0       -10.50000        -.80769
---------------------------------------------------------------------------
                                                     COEF OF        COEF OF
VARIABLE           VARIANCE    STANDARD DEV.        SKEWNESS       KURTOSIS
DIF(ppb)            9.14744          3.02447         -.64362        -.43264
---------------------------------------------------------------------------
                             STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION     OF THE MEAN      LOWER LIMIT     UPPER LIMIT
DIF(ppb)          374.45854          .83884         -2.63583         1.02045
---------------------------------------------------------------------------

                                ORDER STATISTICS



VARIABLE            MAXIMUM          MINIMUM           RANGE       MIDRANGE
DIF(ppb)            3.00000         -7.00000        10.00000       -2.00000
---------------------------------------------------------------------------
```

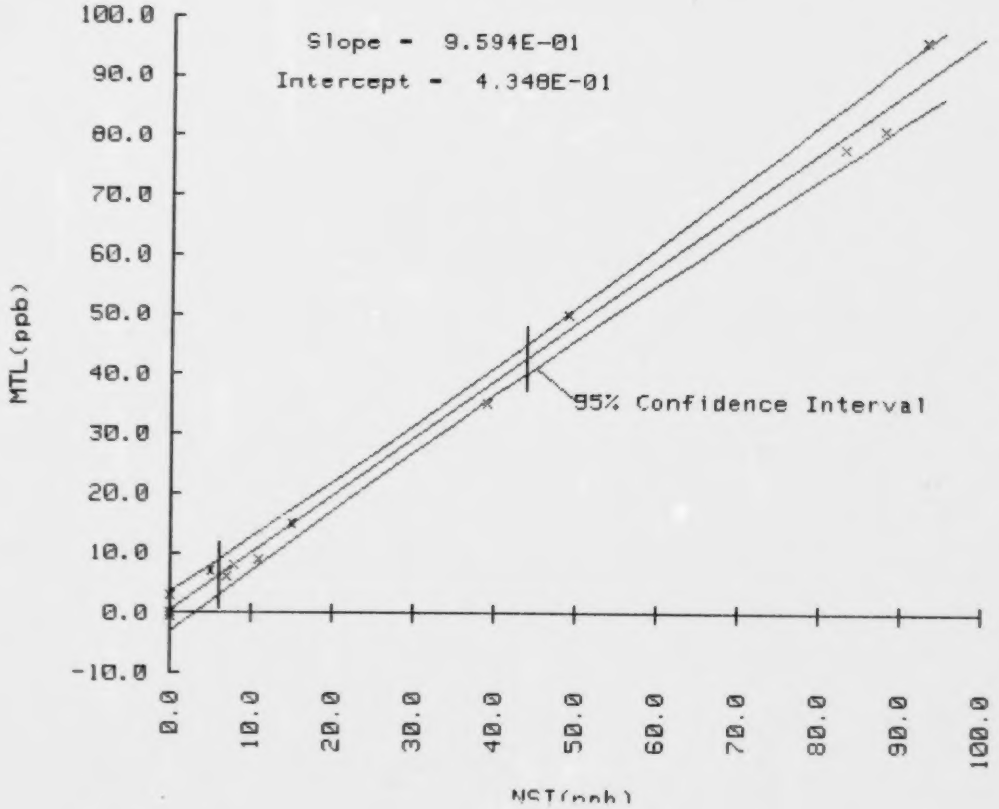

Figure 17. Estimated line of best fit: Audit of Franklin County station for total nitrogen oxides.

TABLE 14. SUMMARY: AUDIT OF FRANKLIN COUNTY STATION FOR SULFUR DIOXIDE

```
        Variable # 1    Variable # 2    Variable # 3
OBS#
   1
           63.00000        71.20000         8.20000
   2
           29.10000        31.90000         2.80000
   3
            4.00000         4.00000         0.00000
   4
            0.00000         1.20000         1.20000
   5
           88.00000        92.00000         4.00000
   6
           40.00000        44.00000         4.00000
   7
            8.00000         8.00000         0.00000
   8
            5.00000         5.00000         0.00000
   9
            0.00000        -1.00000        -1.00000
  10
           97.00000        98.00000         1.00000
  11
           60.00000        61.00000         1.00000
  12
           12.00000        12.00000         0.00000
  13
            7.00000         6.00000        -1.00000
  14
            0.00000         0.00000         0.00000


                          BASIC STATISTICS

VARIABLE      # OBSERVATIONS   # MISS. VALUES            SUM            MEAN
DIF(ppb)                  14                0       20.20000         1.44286
-----------------------------------------------------------------------------
                                                     COEF OF         COEF OF


VARIABLE            VARIANCE   STANDARD DEV.        SKEWNESS        KURTOSIS
DIF(ppb)             6.41341         2.53247         1.47490         1.56503
-----------------------------------------------------------------------------
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION     OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)           175.51775          .67603         -.01972         2.90543
-----------------------------------------------------------------------------

                          ORDER STATISTICS

VARIABLE             MAXIMUM         MINIMUM           RANGE        MIDRANGE
DIF(ppb)             8.20000        -1.00000         9.20000         3.60000
-----------------------------------------------------------------------------
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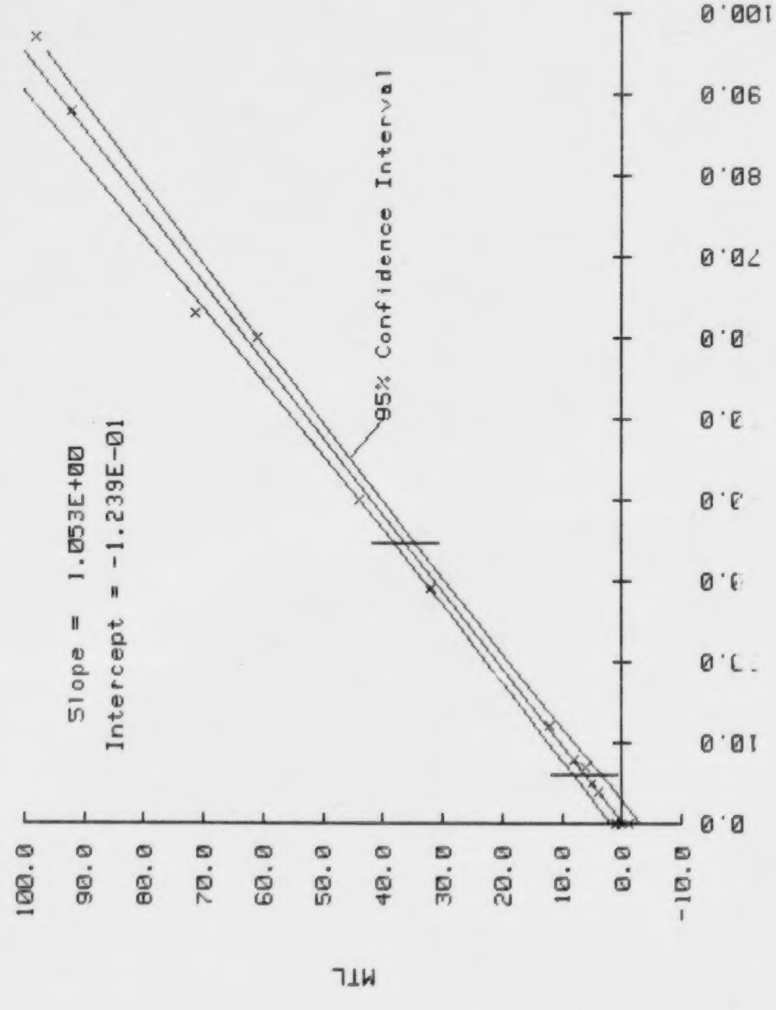

Figure 18. Estimated line of best fit: Audit of Franklin County station for sulfur dioxide.

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TABLE 15. SUMMARY: AUDIT OF ASHLAND COUNTY STATION FOR OZONE

OBS#	Variable # 1	Variable # 2	Variable # 3
1	176.00000	174.00000	-2.00000
2	62.00000	65.00000	3.00000
3	27.00000	27.00000	0.00000
4	6.00000	5.00000	-1.00000
5	0.00000	1.00000	1.00000
6	116.00000	113.00000	-3.00000
7	48.00000	43.00000	-5.00000
8	16.00000	17.00000	1.00000
9	8.00000	13.00000	5.00000
10	0.00000	2.00000	2.00000
11	66.00000	64.00000	-2.00000
12	24.00000	26.00000	2.00000
13	2.00000	4.00000	2.00000
14	0.00000	3.00000	3.00000

```
                              BASIC STATISTICS

VARIABLE        # OBSERVATIONS    # MISS. VALUES          SUM            MEAN
DIF(ppb)                    14                 0      6.00000          .42857
-------------------------------------------------------------------------------
VARIABLE              VARIANCE    STANDARD DEV.       COEF OF         COEF OF
DIF(ppb)               7.49451          2.73761      SKEWNESS        KURTOSIS
                                                      -.35160         -.60617
-------------------------------------------------------------------------------


                                  STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE        COEF VARIATION      OF THE MEAN      LOWER LIMIT      UPPER LIMIT
DIF(ppb)             638.77554           .73166         -1.15248          2.00962
-------------------------------------------------------------------------------

                              ORDER STATISTICS

VARIABLE              MAXIMUM          MINIMUM          RANGE         MIDRANGE
DIF(ppb)              5.00000         -5.00000       10.00000          0.00000
-------------------------------------------------------------------------------
```

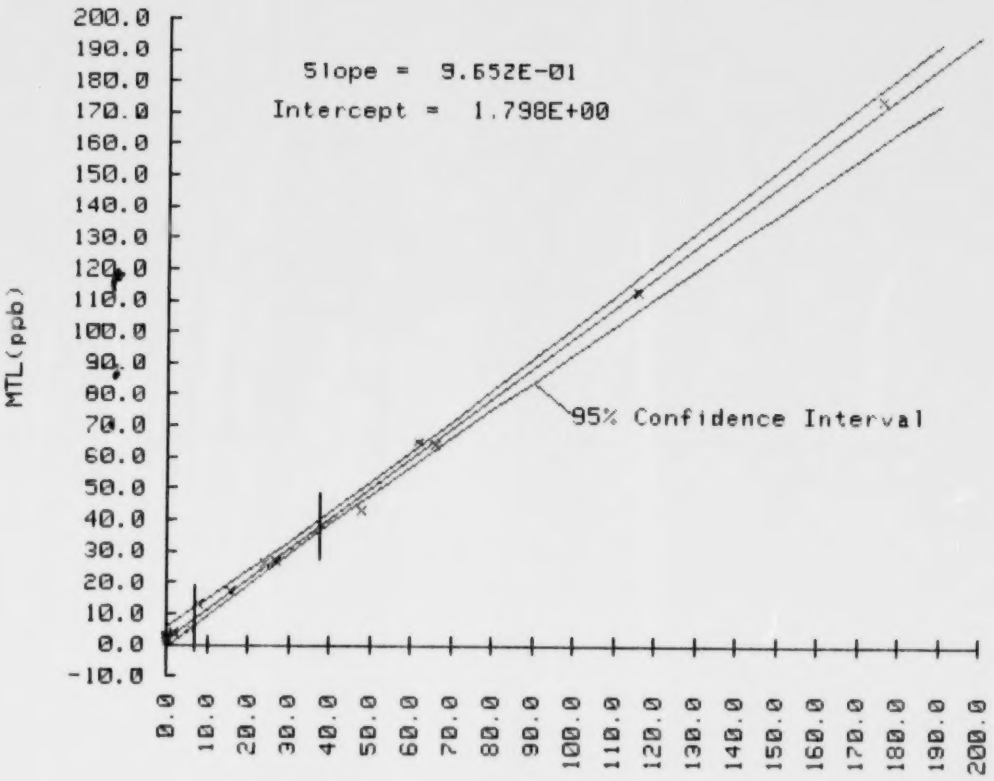

Figure 19. Estimated line of best fit: Audit of Ashland County station for ozone.

TABLE 16. SUMMARY: AUDIT OF ASHLAND COUNTY STATION FOR NITRIC OXIDE

OBS#	Variable # 1	Variable # 2	Variable # 3
1	84.00000	83.00000	-1.00000
2	52.00000	52.00000	0.00000
3	11.00000	11.00000	0.00000
4	0.00000	3.00000	3.00000
5	85.00000	83.00000	-2.00000
6	53.00000	51.00000	-2.00000
7	11.00000	10.00000	-1.00000
8	7.00000	7.00000	0.00000
9	0.00000	0.00000	0.00000
10	93.00000	91.00000	-2.00000
11	51.00000	50.00000	-1.00000
12	18.00000	18.00000	0.00000
13	11.00000	10.00000	-1.00000
14	0.00000	0.00000	0.00000

```
___________________________________BASIC STATISTICS___________________________________

VARIABLE      # OBSERVATIONS    # MISS. VALUES                SUM              MEAN
DIF(ppb)                  14                 0           -7.00000            -.50000
------------------------------------------------------------------------------------

VARIABLE            VARIANCE    STANDARD DEV.             COEF OF           COEF OF
                                                         SKEWNESS          KURTOSIS
DIF(ppb)             1.65385          1.28602             1.23857           2.02380
------------------------------------------------------------------------------------
                                STANDARD ERROR     95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE      COEF VARIATION       OF THE MEAN         LOWER LIMIT       UPPER LIMIT
DIF(ppb)           257.20390            .34370            -1.24271            .24271
------------------------------------------------------------------------------------

__________________________________ORDER STATISTICS__________________________________

VARIABLE             MAXIMUM          MINIMUM               RANGE          MIDRANGE
DIF(ppb)             3.00000         -2.00000             5.00000            .50000
------------------------------------------------------------------------------------
```

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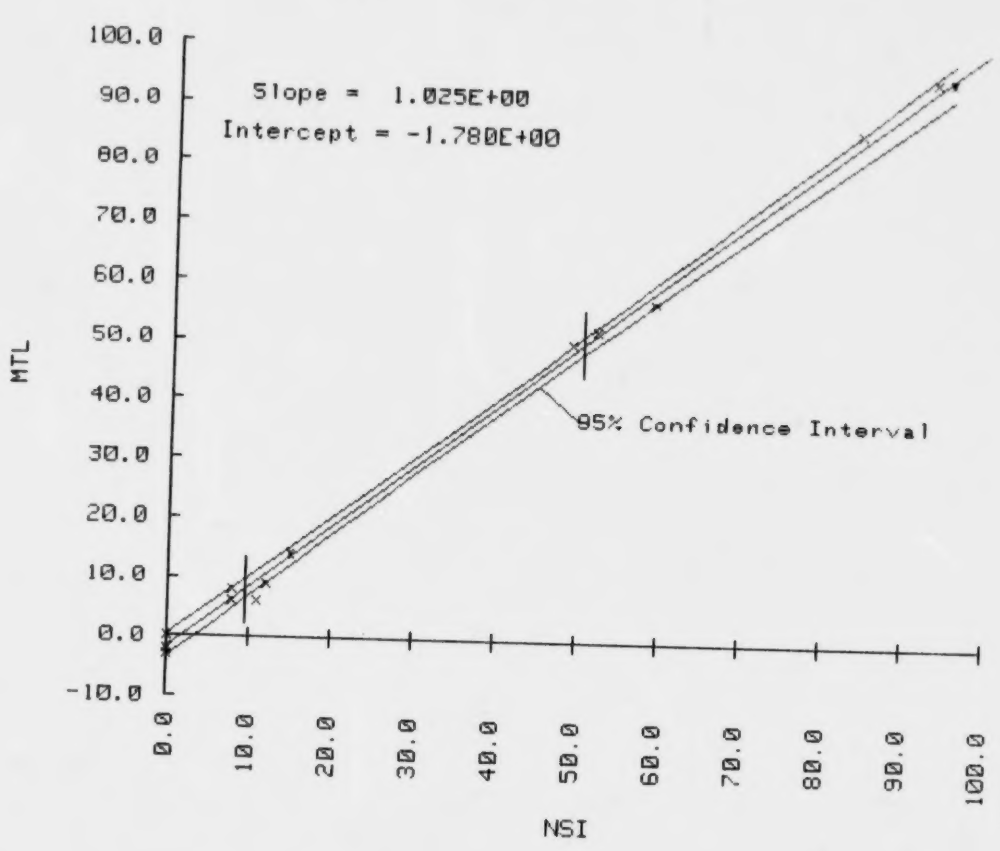


Figure 20. Estimated line of best fit: Audit of Ashland County station for nitric oxide.

TABLE 17. SUMMARY: AUDIT OF ASHLAND COUNTY STATION FOR NITROGEN DIOXIDE

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
   1
          78.00000       60.00000       -2.00000
   2
          13.00000       13.00000        0.00000
   3
           1.00000        0.00000        1.00000
   4
           0.00000       -1.00000        1.00000
   5
          60.00000       59.00000        1.00000
   6
          54.00000       51.00000        3.00000
   7
          16.00000       13.00000        3.00000
   8
           6.00000        3.00000        3.00000
   9
           0.00000        1.00000       -1.00000
  10
          77.00000       78.00000       -1.00000
  11
          31.00000       32.00000       -1.00000
  12
          15.00000       19.00000       -4.00000
  13
           2.00000        4.00000       -2.00000
  14
           0.00000        0.00000        0.00000


                         BASIC STATISTICS

VARIABLE     # OBSERVATIONS   # MISS. VALUES           SUM           MEAN
DIF(ppb)                 14                0       1.00000         .07143
---------------------------------------------------------------------------
                                                   COEF OF        COEF OF
VARIABLE           VARIANCE   STANDARD DEV.       SKEWNESS       KURTOSIS
DIF(ppb)            4.37912         2.09263       -.09760        -.67395
---------------------------------------------------------------------------
                              STANDARD ERROR   95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE     COEF VARIATION      OF THE MEAN     LOWER LIMIT     UPPER LIMIT
DIF(ppb)         2929.68888           .55928       -1.13713         1.27999
---------------------------------------------------------------------------

                         ORDER STATISTICS


VARIABLE            MAXIMUM         MINIMUM          RANGE        MIDRANGE
DIF(ppb)            3.00000        -4.00000        7.00000        -.50000



---------------------------------------------------------------------------
```

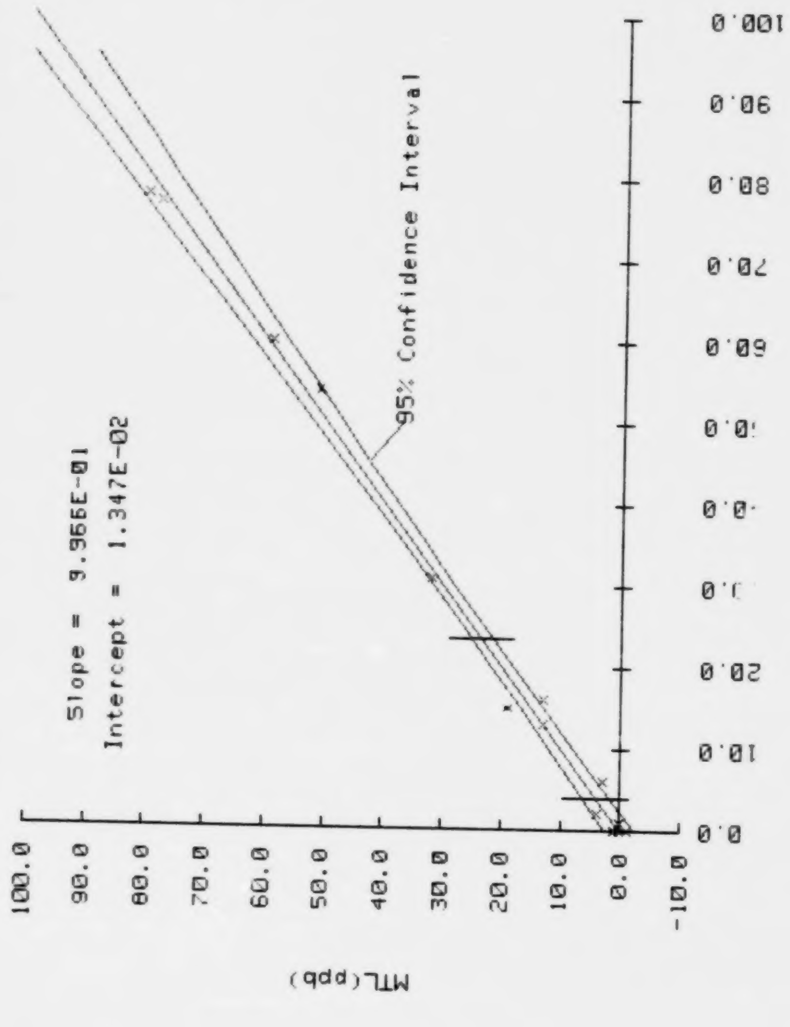


Figure 21. Estimated line of best fit: Audit of Ashland County station for nitrogen dioxide.

TABLE 18. SUMMARY: AUDIT OF ASHLAND COUNTY STATION FOR TOTAL NITROGEN OXIDES

```
        Variable # 1   Variable # 2   Variable # 3
OBS#
   1
          84.00000       86.00000        2.00000
   2
          52.00000       52.00000        0.00000
   3
          11.00000        6.00000       -5.00000
   4
           0.00000       -3.00000       -3.00000
   5
          95.00000       95.00000        0.00000
   6
          59.00000       57.00000       -2.00000
   7
          12.00000        9.00000       -3.00000
   8
           8.00000        6.00000       -2.00000
   9
           0.00000       -2.00000       -2.00000
  10
          93.00000       95.00000        2.00000
  11
          49.00000       50.00000        1.00000
  12
          15.00000       14.00000       -1.00000
  13
           8.00000        8.00000        0.00000
  14
           0.00000        0.00000        0.00000


                           BASIC STATISTICS

VARIABLE    # OBSERVATIONS    # MISS. VALUES              SUM              MEAN
DIF(ppb)                14                 0        -13.00000           -.92857
--------------------------------------------------------------------------------
                                                      COEF OF           COEF OF
VARIABLE          VARIANCE    STANDARD DEV.          SKEWNESS          KURTOSIS
DIF(ppb)           4.07143          2.01778           -.27545           -.60383
--------------------------------------------------------------------------------
                             STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN
VARIABLE    COEF VARIATION      OF THE MEAN       LOWER LIMIT       UPPER LIMIT
DIF(ppb)         217.29918           .53927          -2.09390            .23676
--------------------------------------------------------------------------------

                           ORDER STATISTICS

VARIABLE
DIF(ppb)           MAXIMUM          MINIMUM             RANGE          MIDRANGE
                   2.00000         -5.00000           7.00000          -1.50000
--------------------------------------------------------------------------------
```

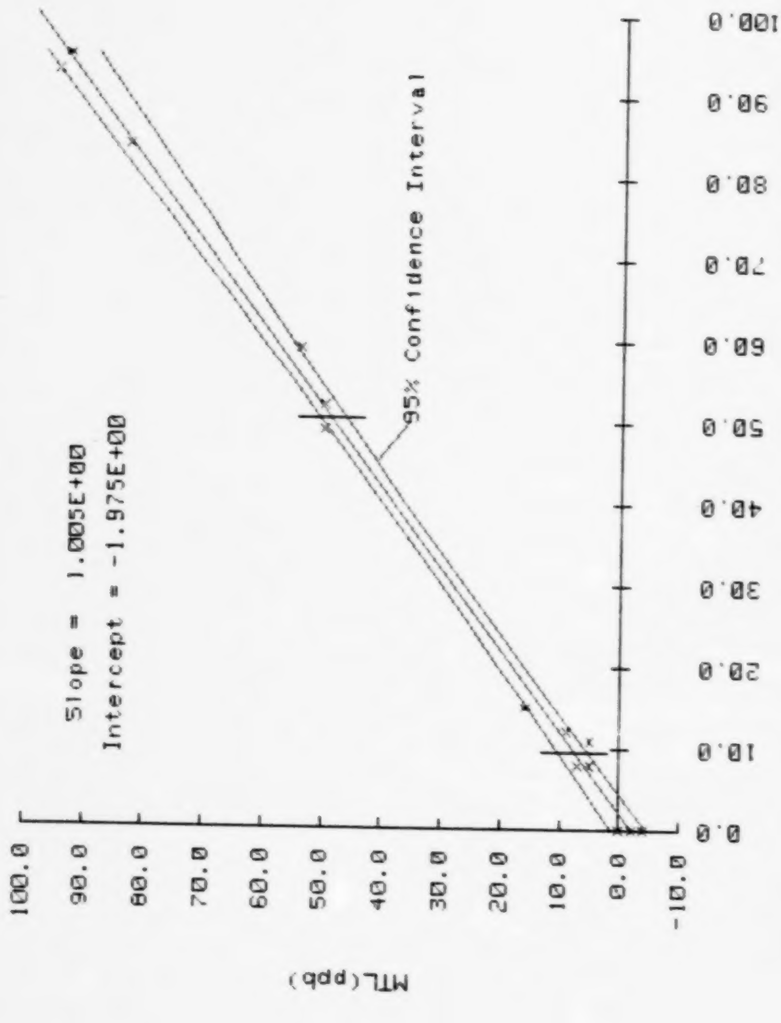


Figure 22. Estimated line of best fit: Audit of Ashland County station for total nitrogen oxides.

TABLE 19. SUMMARY: AUDIT OF ASHLAND COUNTY STATION FOR SULFUR DIOXIDE

```
         Variable # 1    Variable # 2    Variable # 3
OBS#
   1
            86.00000        96.80000        10.80000
   2
            52.50000        59.80000         7.30000
   3
             9.60000        11.30000         1.70000
   4
             4.20000         6.10000         1.90000
   5
             0.00000         1.40000         1.40000
   6
            93.00000        96.00000         3.00000
   7
            44.00000        43.00000        -1.00000
   8
             9.00000         4.00000        -5.00000
   9
             6.00000        -2.00000        -8.00000
  10
             0.00000        -4.00000        -4.00000
  11
            80.00000        81.00000         1.00000
  12
            59.00000        58.00000        -1.00000
  13
            11.00000        12.00000         1.00000
  14
             7.00000         7.00000         0.00000
  15
             0.00000        -2.00000        -2.00000


                              BASIC STATISTICS

VARIABLE     # OBSERVATIONS    # MISS. VALUES
DIF(ppb)                 15                 0             SUM            MEAN
                                                      7.10000          .47333
-------------------------------------------------------------------------------
VARIABLE           VARIANCE    STANDARD DEV.          COEF OF         COEF OF
DIF(ppb)           21.21638          4.60612         SKEWNESS        KURTOSIS
                                                       .42287          .41593
-------------------------------------------------------------------------------
                             STANDARD ERROR    95 % CONFIDENCE INTERVAL ON MEAN


VARIABLE      COEF VARIATION      OF THE MEAN      LOWER LIMIT     UPPER LIMIT
DIF(ppb)           973.12485          1.10930         -2.07810         3.02476
-------------------------------------------------------------------------------

                              ORDER STATISTICS

VARIABLE
DIF(ppb)            MAXIMUM          MINIMUM            RANGE        MIDRANGE
                   10.80000         -8.00000         18.80000         1.40000
-------------------------------------------------------------------------------
```

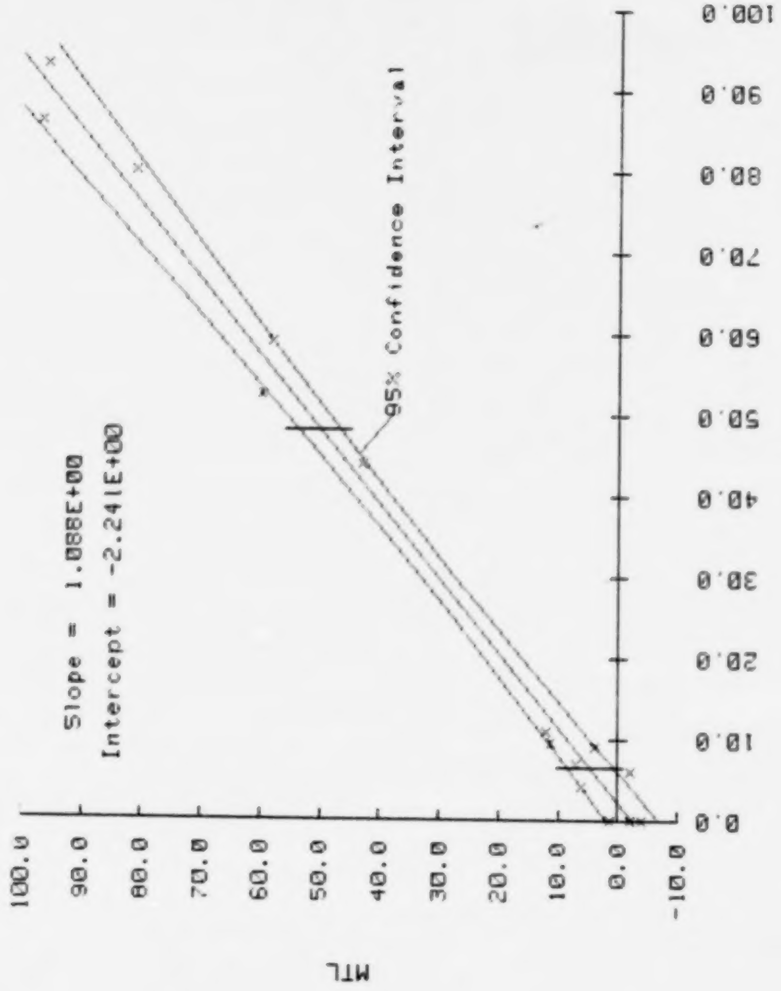


Figure 23. Estimated line of best fit: Audit of Ashland County station for sulfur dioxide.

TABLE 20. STATION GRADES: CONTINUOUS ANALYZERS

Station	Pollutant	Grade[*]
Union County, Kentucky	O_3	96.8
	NO	101.3
	NO_2	88.1
	NO_x	99.6
	SO_2	91.2
Franklin County, Indiana	O_3	95.1
	NO	90.2
	NO_2	99.4
	NO_x	82.3
	SO_2	96.3
Ashland County, Ohio[†]	O_3	87.2
	NO	88.8
	NO_2	86.2
	NO_x	83.6
	SO_2	73.6

[*] Grades were calcuated as described in Section 5. 100% is perfect; 70% is unacceptable.

[†] Results for Perrysville SO_2 are for one audit only (August 8, 1980). This analyzer was nonoperational on the other two audits.

TABLE 22. STATION GRADES:
PARTICULATE SAMPLERS AND METEOROLOGICAL SENSORS

Station	Instrument*	Mean Percent Difference	Grade†
Union County	high volume sampler	2.2	95.6
	nephelometer	4.4	91.2
	dichotomous sampler	2.8	94.4
	temperature sensor	-	-
	barometer	0.6	98.8
	wind direction sensor	-	-
	dew point sensor	-	-
Franklin County	high volume sampler	3.6	92.8
	nephelometer	3.2	93.6
	dichotomous sampler	4.1	91.8
	temperature sensor	-	-
	barometer	0.8	98.4
	wind direction sensor	-	-
	dew point sensor	-	-
Ashland County	high volume sampler	2.8	94.4
	nephelometer	6.3	87.4
	dichotomous sampler	5.3	89.4
	temperature sensor	-	-
	barometer	0.3	99.4
	wind direction sensor	-	-
	dew point sensor	-	-

*Grades are not given for the wind direction sensor. However, the audit values obtained for this instrument were within the limits of measurement for the audit device (±10°); thus, for purposes of comparison, a grade of 100 would be assigned.

†Grades were calculated as described in Section 5.

APPENDIX A

QAD STATEMENTS OF AUDIT CERTIFICATION COMPARISON RESULTS

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

November 12, 1980

Mr. Joe Williams
Northrop Services
P.O. Box 12313
RTP, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3 and SO_2 audit system with our laboratory system on November 4, 1980.

Gas - NO

QAD (ppm)	NSI (ppm)
0.000	0.000
.084	.084
.053	.055
.010	.011
.006	.0068

NSI = 1.0008 (QAD) + 0.0007 $R^2 = .9997$

Gas - NO_2

QAD (ppm)	NSI (ppm)
0.000	0.000
.063	.061
.055	.053
.015	.013
.004	.004

NSI = .9708 (QAD) - 0.0004 $R^2 = .9997$

Gas - O_3

QAD (ppm)	NSI (ppm)
0.000	0.000
.185	.184
.088	.091
.037	.038
.014	.018

NSI = .9875 (QAD) + 0.0022 $R^2 = .9999$

Gas - SO_2	QAD (ppm)	NSI (ppm)
	0.000	0.000
	.087	.0865
	.064	.061
	.0068	.008
	.0038	.005

NSI = .9713 (QAD) + 0.7489 $R^2 = .9995$

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: J. Puzak
R. Baumgardner
J. Bowen

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

February 3, 1981

Mr. Joe Williams
Northrop Services, Inc.
P.O. Box 12313
Pesearch Triangle Park, NC 27709

Dear Joe:

I have listed the results of the comparison of your NO, NO_2, O_3 and SO_2 audit with our laboratory system on December 26, 1980.

Gas - NO

QAD (ppb)	Northrop (ppb)
0.000	0.000
92.0	93.0
57.0	58.0
10.0	11.0
5.0	7.0

Northrop = 1.007 (QAD) + 0.0009 R^2 = .9998

Gas - NO_2

QAD (ppb)	Northrop (ppb)
0.000	0.000
85.0	86.0
60.0	62.0
15.0	19.0
2.5	7.0

Northrop = 0.9831 (QAD) + 0.0028 R^2 = .9998

Gas - O_3

QAD (ppb)	Northrop (ppb)
0.000	0.000
177.0	178.0
80.0	83.0
46.0	47.0
14.0	17.0

Northrop = 0.9998 (QAD) + 0.0016 R^2 = .9998

Gas - SO_2	QAD (ppb)	Northrop (ppb)
	0.000	0.000
	4.9	5.2
	8.0	8.2
	41.0	42.6
	87.0	88.0

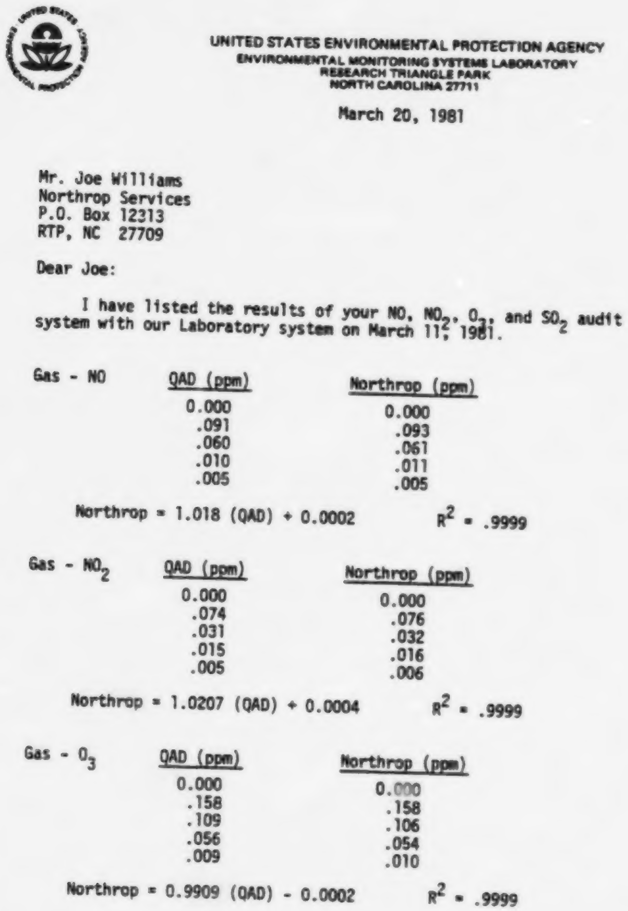
Northrop = 1.0127 (QAD) + 0.2614 $R^2 = .9999$

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: J.C. Puzak
R.E. Baumgardner
J.A. Bowen



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
ENVIRONMENTAL MONITORING SYSTEMS LABORATORY
RESEARCH TRIANGLE PARK
NORTH CAROLINA 27711

March 20, 1981

Mr. Joe Williams
Northrop Services
P.O. Box 12313
RTP, NC 27709

Dear Joe:

I have listed the results of your NO, NO_2, O_3, and SO_2 audit system with our Laboratory system on March 11, 1981.

Gas - NO	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.091	.093
	.060	.061
	.010	.011
	.005	.005

Northrop = 1.018 (QAD) + 0.0002 R^2 = .9999

Gas - NO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.074	.076
	.031	.032
	.015	.016
	.005	.006

Northrop = 1.0207 (QAD) + 0.0004 R^2 = .9999

Gas - O_3	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.158	.158
	.109	.106
	.056	.054
	.009	.010

Northrop = 0.9909 (QAD) - 0.0002 R^2 = .9999

Gas - SO_2	QAD (ppm)	Northrop (ppm)
	0.000	0.000
	.082	.086
	.035	.036
	.007	.007

Northrop = 1.050 (QAD) - 0.0003 R^2 = .9999

The Northrop measurements are in good agreement with the QAD system.

Sincerely yours,

O.L. Dowler
Quality Assurance Division
Environmental Monitoring
Systems Laboratory

cc: J.C. Puzak
R.E. Baumgardner

APPENDIX B

RESULTS OF STATION AUDITS

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

NOVEMBER 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
062126	Morganfield Kentucky	NEPHELOMETER (MRI)		BACKGROUND	0.0	.020	0.4	
			Operative	Cal	4.000	3.950	-1.25	
				dark	0.0	0.002	0.0	
				Freon	1.200	1.243	3.6	
	Morganfield Kentucky	DICHOTOMOUS (Beckman)	Operative	Total Flow	16.7	16.77	0.5	
				Fine Flow	15.0	15.24	1.6	
				Coarse Flow	1.7	1.55	-8.8	
	Morganfield Kentucky	CLIMET	Operative	Temp.	3.1	3.17	-2.2	
			"	Barometer	754	754.02	0.0	
			"	Wind Dir.	---	------	---	Audit not performed
			"	Wind Speed				due to weather
			"	Dewpoint	3.1	1.30	-58.1	
				Solar Radiation				
08103	Brookville Indiana	NEPHELOMETER (MRI)	Operative	BACKGROUND	0.0	0.0	0.0	
				Cal	4.00	3.83	-4.3	
				dark	0.0	0.002	0.0	
				Freon	1.20	1.24	3.3	
	Brookville Indiana	DICHOTOMOUS (Beckman)	Inoperative	Total Flow				Jack screw
				Fine Flow				bearings seized
				Coarse Flow				

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

NOVEMBER 1980

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
			Operative					
	Brookville Indiana	CLIMET	Operative	Temp.	+ 2.8	2.45	-12.5	
			"	Barometer	749	746	-0.4	
			"	Wind Dir.	259°	260°	0.4	
			"	Wind Speed				
			"	Dewpoint	- 2.1	-5.36	-155.00	
				Solar Radiation				
082042	Perrysville Ohio	NEPHELOMETER (MRI)	Operative	BACKGROUND	0.0	-0.004	0.0	
				Cal	4.0	4.065	1.6	
				dark	0.0	0.001	0.0	
				Freon	1.20	1.427	18.9	
	Perrysville Ohio	DICHOTOMOUS (Beckman)	Operative	Total Flow	16.7	16.2	-3.0	
				Fine Flow	15.0	14.4	-4.0	
				Coarse Flow	1.7	1.8	5.9	
	Perrysville Ohio	CLIMET	Operative	Temp.	3.0	2.51	-16.3	
				Barometer	735	734.43	0.0	
				Wind Dir.	198	217	-----	
				Wind Speed				
				Dewpoint	-4.2	-4.5	7.1	
				Solar Radiation				

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
002120	Morganfield Kentucky	Bendix S/N 13162-2	O_3				1.0042	0.1600	.9999
				168.0	167.0	1.0			
				64.0	64.0	0.0			
				37.0	37.0	0.0			
				22.0	23.0	1.0			
				4.2	4.4	0.2			
				0.0	-0.3	.3			
002103	Brookville Indiana	Bendix S/N 13162-1	O_3	180.0	187.0	7.0	1.0378	.0351	.9999
				68.0	70.0	2.0			
				26.0	27.5	0.5			
				0.0	0.0	0.0			
002042	Perrysville Ohio	Bendix S/N 13162-3	O_3	176.0	174.0	-2.0	.9899	.7755	.9996
				62.0	65.3	3.0			
				27.0	27.0	0.0			
				5.8	4.5	-1.3			
				0.0	1.1	1.1			

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Morganfield Kentucky	CSI S/N 9895	NO	88.9	89.9		1.0033	.3541	.9999
				55.0	55.0				
				11.3	11.6				
				7.2	7.4				
				0.0	0.8				
062103	Brookville Indiana	CSI S/N 9707	NO	83.1	78.2		.9475	-.8359	.9999
				38.7	35.2				
				7.0	5.8				
				0.0	-.5				
062042	Perrysville Ohio	CSI S/N 9894	NO	84.0	85.7		1.0918	-5.7042	.9999
				52.0	51.5				
				10.5	6.2				
				0.0	-3.0				

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
002126	Morganfield Kentucky	CSI S/N 9895	NO_2	86.8	80.6		.9908	-6.3696	.9781
				57.8	53.2				
				17.3	10.9				
				5.2	-.2				
				0.0	2.2				
002103	Brookville Indiana	CSI S/N 9707	NO_2	76.6	79.4		1.0172	.9002	.9998
				45.4	46.1				
				0.0	1.3				
002042	Perrysville Ohio	CSI S/N 9894	NO_2	78.0	80.1		1.0387	-.9425	.9997
				13.2	12.6				
				1.1	.4				
				0.0	-1.0				

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Morganfield Kentucky	CSI S/N 9895	NO_x	84.0	83.4		.9671	1.9300	.9998
				52.0	52.0				
				10.5	11.3				
				0.0	2.7				
062103	Brookville Indiana	CSI S/N 9707	NO_x	83.1	80.4		.9687	-.7424	.9995
				38.7	35.5				
				7.0	5.3				
				0.0	.6				
062042	Perrysville Ohio	CSI S/N 9894	NO_x	84.0	83.2		1.0814	-7.1383	.9996
				52.0	50.0				
				10.5	5.1				
				0.0	-4.0				

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
002120	Morganfield Kentucky	MELOY S/N 8L049	SO_2						
				0	2.1	Inoperative (?)			
				84.8	77.4	would not			
						equilibrate			
002103	Brookville Indiana	MELOY S/N 5L042	SO_2	63.0	71.2	Operator check	1.1209	.1459	.9996
				29.1	31.9	disagreed with			
				4.0	4.0	NSI			
				0.0	1.2				
002042	Perrysville Ohio	MELOY S/N 8K08	SO_2	86.0	96.8	Low H_2 supply	1.1125	1.1925	.9999
				52.5	59.8				
				9.6	11.3				
				4.2	6.1	Comparison of			
				0.0	1.4	calibration			
						systems revealed			
						discrepancy			

CONTINUOUS ANALYZERS

NOVEMBER 1980

STATION NUMBER	STATION NAME	HI-VOL	AUDIT LEVEL	RESPONSE	REMARKS	REGRESSION OF RESPONSE m	b	r
062126	Morganfield Kentucky				Not audited due to rain...			
062103	Brookville Indiana		64.5	63.7		.9518	.9908	.9966
			59.1	56.1				
			52.3	50.3				
			42.3	40.9				
			33.9	33.9				
062042	Perrysville Ohio		64.4	62.6		.9785	1.1649	.9817
			53.8	57.8				
			51.2	49.6				
			41.6	41.5				
			32.4	32.5				

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

JANUARY 1981

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
002120	Union County Kentucky	NEPHELOMETER (MRI)		BACKGROUND	0.000	.005		
			operative	Cal	4.0	3.7		
				dark	0.0	.002		
				Freon	1.20	1.250		
		DICHOTOMOUS (Beckman)	operative	Total Flow	16.7	16.9		Pressure switch
				Fine Flow	15.0	15.1		actuated at 14.7
				Coarse Flow	1.7	1.8		
		CLIMET	operative	Temp.	7.5	7.0		
				Barometer	756	755		
				Wind Dir.				
				Wind Speed				
			$3^{o}C^{(W)}7^{o}C^{(D)}$	Dewpoint	.2	-5.4		
				Solar Radiation				
08103	Franklin County Indiana	NEPHELOMETER (MRI)	operative	BACKGROUND	0.0	.004		
				Cal	4.0	4.07		
				dark	0.0	.002		
				Freon	1.20	1.20		
		DICHOTOMOUS (Beckman)	operative	Total Flow	16.7	16.8		pressure switch
				Fine Flow	15.0	14.9		actuated at 14.2
				Coarse Flow	1.7	1.9		

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

JANUARY 1981

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
082120	Franklin County Indiana			BACKGROUND				
		CLIMET	operative	Temp.	2.8	2.5	-10.7	
				Barometer	741.5	740.3	0.2	
				Wind Dir.	364±10	363	---------	
				Wind Speed				
				Dewpoint	0.8°	-1.4	---------	
				Solar Radiation	-------			
082042	Ashland County Ohio	NEPHELOMETER (MRI)	operative	BACKGROUND	0.0	-.065V	---------	Span set at
				Cal	4.00	4.03V	0.8	maximum gain
				dark	0.00	-.020V	---------	
				Freon	1.20	1.015V	-15.4	
		DICHOTOMOUS (Beckman)	operative	Total Flow	16.7	16.5	-1.2	pressure switch
				Fine Flow	15.0	14.6	-2.7	actuated at 14.2
				Coarse Flow	1.7	1.9	11.8	
		CLIMET	operative	Temp.	-2.0	-1.4	-30.0	
				Barometer	734	727	-1.0	
				Wind Dir.	249 ± 10	242	---------	
				Wind Speed				
				Dewpoint				Below Freezing
				Solar Radiation				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Union County Kentucky	Bendix S/N 13162-2	O_3	153.0	142.6		0.9283	0.7693	.9999
				57.0	54.3				
				20.0	19.4				
				11.0	11.8				
				0.0	-0.4				
062103	Franklin County Indiana	Bendix S/N 13162-1	O_3	120.0	115.9		0.9530	1.4528	.9997
				53.0	51.3				
				16.0	17.7				
				8.0	10.1				
				0.0	0.0				
062042	Ashland County Ohio	Bendix S/N 13162-3	O_3	116.0	113.4		0.9482	1.9271	.9982
				48.0	43.4				
				16.0	16.9				
				8.0	12.7				
				0.0	1.5				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Union County Kentucky	CSI	NO_x						
		S/N: 9895		85.0	83.4		.9780	-0.0177	.9999
				52.5	50.9				
				10.6	10.3				
				6.9	6.5				
				0.0	0.4				
062103	Franklin County Indiana	CSI	NO_x						
		S/N: 9707		88.0	81.4		.9057	1.476	.9993
				10.7	9.1				
				5.3	6.8				
				0.0	2.8				
062042	Ashland County Ohio	CSI	NO_x						
		S/N: 9894		94.7	93.3		1.0042	-2.9060	.9996
				58.6	54.2				
				12.0	9.0				
				7.5	4.5				
				0.0	-2.0				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE m	b	r
062128	Union c County Kentucky	CSI S/N 9895	NO	85.0	87.4				
				52.5	54.3		1.0323	-0.2014	.9999
				10.6	10.4				
				6.9	6.9				
				0.0	0.0				
062103	Franklin County Indiana	CSI S/N 9707	NO	88.0	81.7		.9375	-0.7989	.9998
				10.7	8.6				
				5.3	5.4				
062042	Ashland County Ohio	CSI S/N 9894	NO	94.7	95.3		1.0257	-2.3087	.9998
				58.6	57.1				
				12.0	9.1				
				7.5	6.3				
				0.0	-2.1				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Union County Kentucky	CSI S/N 9895	NO_2	56.0	51.7		.9609	-2.2653	.9967
				53.0	49.3				
				17.0	12.9				
				9.0	3.9				
				0.0	0.6				
062103	Franklin County Indiana	CSI S/N 9894	NO_2	54.0	49.8		.8880	1.9156	.9998
				11.0	11.9				
				2.5	4.6				
				0.0	1.3				
062042	Ashland County Ohio	CSI S/N 9894	NO_2	60.4	58.7		.9851	-1.5724	.9982
				54.0	51.2				
				15.8	13.3				
				6.4	2.7				
				0.0	0.8				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062128	Union County Kentucky	MELOY S/N 8L049	SO_2	83.8	92.4		1.1350	-3.2250	.9984
				39.0	40.6				
				7.8	3.0				
				5.1	1.6				
				0.0	0.3				
062103	Franklin County Indiana	MELOY S/N 5L042	SO_2	88.2	91.8		1.0508	-0.0883	.9996
				40.1	43.8				
				7.5	7.9				
				4.8	4.7				
				0.0	-0.9				
062042	Ashland County Ohio	MELOY S/N 8K08	SO_2	93.4	95.5		1.0845	-5.5201	.9994
				43.5	42.5				
				8.9	4.4				
				5.6	-1.8				
				0.0	-4.0				

CONTINUOUS ANALYZERS

JANUARY 1981

STATION NUMBER	STATION NAME	HI-VOL		AUDIT LEVEL	RESPONSE	REMARKS	REGRESSION OF RESPONSE		
							m	b	r
062126	Union County Kentucky	12.6	18	58.5	59.2		.9704	2.250	.9981
		11.4	13	53.4	53.1				
		7.8	10	46.4	48.2				
		5.6	7	37.5	38.9				
		2.3	5	28.9	29.9				
062103	Franklin County Indiana			58.7	61.0		1.0704	-1.6589	.9995
				52.4	55.0				
				47.4	48.6				
				38.3	39.4				
				30.4	30.9				
062042	Ashland County Ohio					Audit not performed due to weather.			

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

MARCH 1981

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
062126	Union County Kentucky	NEPHELOMETER (MRI)	operative	BACKGROUND	0.000	-0.012		operator states
				Cal	4.000	5.300	30.2	drift excessive.
				dark	0.000	-0.005		
				Freon	1.200	1.460	21.6	
		DICHOTOMOUS (Beckman)	operative,	Total Flow	16.70	16.60	0.6	cutoff at
				Fine Flow	15.00	15.00	0.0	15.1 l/min.
				Coarse Flow	1.70	1.60	-5.9	
		CLIMET	operative	Temp.	6.5° C	5.0° C	-23.1	
				Barometer	758.0	772.0	1.8	
				Wind Dir.	316 ± 10	311.0		
				Wind Speed				
				Dewpoint	-2.5° C	-7.8° C		
				Solar Radiation				
08103	Franklin County Indiana	NEPHELOMETER (MRI)	operative	BACKGROUND	0.000	-0.014		
				Cal	4.000	4.000	0.0	
				dark				
				Freon	1.200	1.083	-9.8	
		DICHOTOMOUS (Beckman)	operative	Total Flow	16.70	16.36	-2.0	
				Fine Flow	15.00	14.73	1.8	
				Coarse Flow	1.70	1.57	7.6	

PARTICULATE AND METEOROLOGICAL SAMPLING EQUIPMENT

MARCH 1981

STATION NUMBER	STATION NAME	INSTRUMENT	STATUS	PARAMETER MEASURED	DESIRED RESPONSE	OBSERVED RESPONSE	PERCENT DIFFERENCE	REMARKS
06103	Franklin County Indiana	CLIMET	operative	Temp.	0.0° C	-2.2° C		
				Barometer	721.0	733.0	1.7	
				Wind Dir.	26 ± 10	21.2		
				Wind Speed				
				Dewpoint	-4.2° C	-10.6° C		
				Solar Radiation				
062042	Ashland County Ohio	NEPHELOMETER (MRI)	operative	BACKGROUND	0.000	-0.023		
				Cal	4.000	4.050	1.3	
				dark	0.000			
				Freon	1.200	1.200		
		DICHOTOMOUS (Beckman)	operative	Total Flow	16.70	16.40	1.8	cutoff at
				Fine Flow	15.00	15.00	0.0	13.2 l/min.
				Coarse Flow	1.70	1.40	17.6	
		CLIMET	operative	Temp.	-6.0° C	6.6° C		
				Barometer	718.0	717.0	0.0	
				Wind Dir.	272 ± 10	262.0		
				Wind Speed				
				Dewpoint	----------	--not done--	----------	Below freezing
				Solar Radiation				

CONTINUOUS ANALYZERS

MARCH 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE m	b	r
062126	Union County Kentucky	Bendix S/N 13162-2	O_3	0.0	-3.2		0.98	-2.2	0.9998
				5.0	2.6				
				40.0	39.5				
				74.0	69.3				
				176.0	171.0				
062103	Franklin County Indiana	Bendix S/N 13162-1	O_3			No audit.			
062042	Ashland County Ohio	Bendix S/N 13162-3	O_3	0.0	2.8		0.94	2.6	0.9996
				2.0	3.6				
				24.0	26.0				
				66.0	64.0				

CONTINUOUS ANALYZERS

MARCH 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062128	Union County Kentucky	Meloy S/N 8L049	SO_2	0.0	-0.2	nonlinear	1.18	-5.4	0.9969
				6.6	1.0				
				11.2	3.2				
				57.6	61.8				
				92.2	104.2				
062103	Franklin County Indiana	Meloy S/N 5L042	SO_2	0.0	-0.4		1.02	-0.68	0.9999
				7.2	6.2				
				12.0	11.7				
				59.9	60.6				
				96.8	98.1				
062042	Ashland County Ohio	Meloy S/N 8K08	SO_2	0.0	-1.8		1.01	-0.64	0.9997
				6.9	7.1				
				11.4	11.7				
				58.6	58.0				
				80.4	81.2				

CONTINUOUS ANALYZERS

MARCH 1981

TATION UMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Union County Kentucky	CSI S/N 9895	NO	0.0	-0.3	4-6 ppb noise	1.03	-0.275	0.9999
				10.7	10.7				
				18.1	18.1				
				50.9	52.7				
				93.4	95.6				
062103	Franklin County Indiana	CSI S/N 9707	NO	0.0	-0.1	4-6 ppb noise	1.003	-0.592	0.9999
				7.8	6.4				
				15.0	14.6				
				49.0	48.9				
				93.0	92.6				
062042	Ashland County Ohio	CSI S/N 9894	NO	0.0	0.0	4-6 ppb noise	1.019	-0.368	0.9999
				8.0	8.1				
				15.0	14.2				
				49.0	49.5				
				93.0	94.6				

CONTINUOUS ANALYZERS

MARCH 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Union County Kentucky	CSI S/N 9895	NO_2	0.0	-0.3	4-6 ppb noise	0.96	-1.19	0.9998
				18.5	16.1				
				29.7	26.4				
				63.5	59.7				
				82.2	78.0				
062103	Franklin County Indiana	CSI S/N 9707	NO_2	0.0	-0.4	4-6 ppb noise	0.98	0.60	0.9998
				5.3	4.3				
				18.8	18.6				
				42.0	39.6				
				81.6	79.9				
062042	Ashland County Ohio	CSI S/N 9894	NO_2	0.0	0.0	4-6 ppb noise	0.99	2.00	0.9989
				1.50	4.12				
				14.8	18.7				
				30.7	31.9				
				76.8	77.8				

CONTINUOUS ANALYZERS

MARCH 1981

STATION NUMBER	STATION NAME	ANALYZER AND S/N	POLLUTANT	AUDIT LEVEL ppb	ANALYZER RESPONSE	REMARKS	REGRESSION OF ANALYZER RESPONSE		
							m	b	r
062126	Union County Kentucky	CSI S/N 9895	NO_x	0.0	0.0	4-6 ppb noise	0.98	-0.12	0.9999
				10.7	9.8				
				18.1	17.6				
				50.9	50.2				
				93.4	90.7				
062103	Franklin County Indiana	CSI S/N 9707	NO_x	0.0	0.5	4-6 ppb noise	1.03	-0.08	1.0000
				7.8	7.6				
				15.0	15.1				
				49.0	50.3				
				93.0	95.8				
062042	Ashland County Ohio	CSI S/N 9894	NO_x	0.0	0.4	4-6 ppb noise	1.02	-0.10	0.9999
				8.0	7.0				
				15.0	15.6				
				49.0	50.2				
				93.0	94.7				

CONTINUOUS ANALYZERS

MARCH 1981

STATION NUMBER	STATION NAME	HI-VOL	AUDIT LEVEL	RESPONSE	REMARKS	REGRESSION OF RESPONSE		
						m	h	r
062126	Union County Kentucky		58.3	58.6		0.9831	0.0296	0.9958
			54.8	52.2				
			47.9	47.6				
			38.5	37.7				
			28.7	28.4				
062103	Franklin County Indiana		64.1	61.4		0.8822	4.1820	0.9961
			58.7	56.0				
			51.8	49.5				
			43.1	40.8				
			32.9	34.3				
062042	Ashland County Ohio				Audit not performed due to weather.			